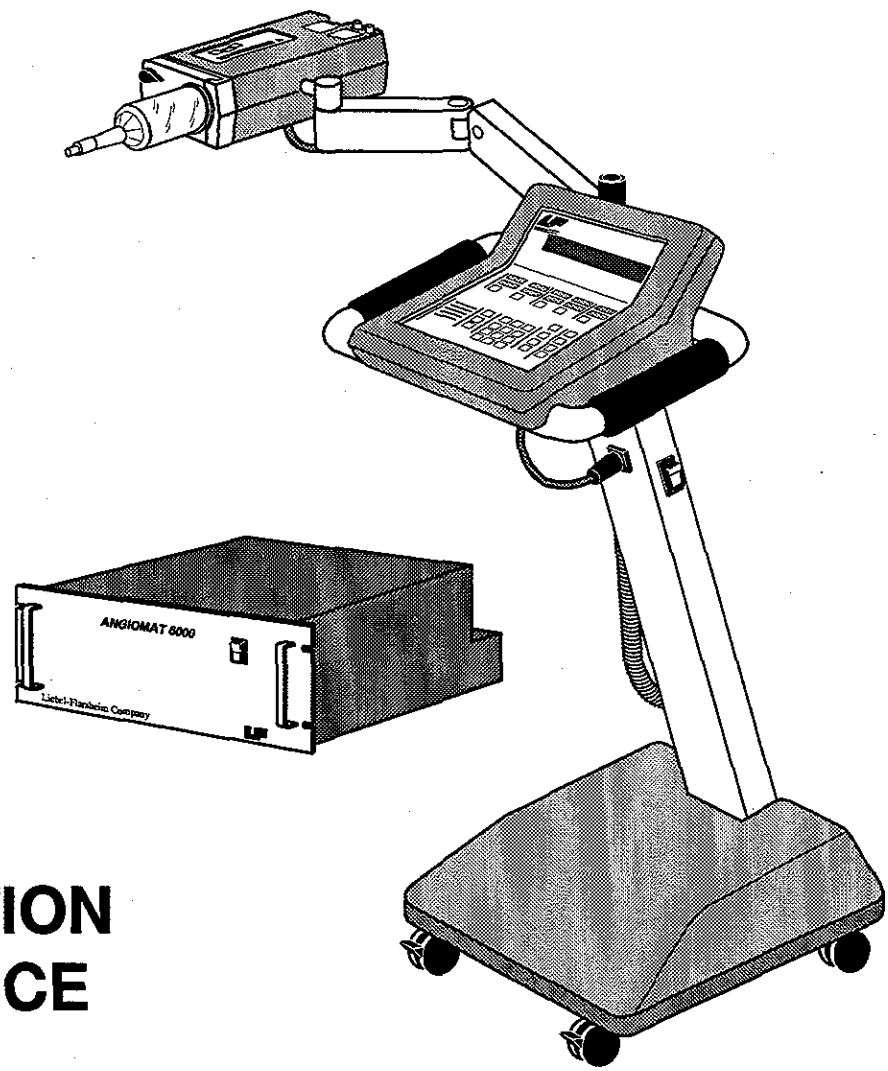
ANGIOMAT 6000
DIGITAL INJECTION SYSTEM

601910
Rev B



INSTALLATION AND SERVICE MANUAL

Liebel-Flarsheim Company
2111 EAST GALBRAITH ROAD, CINCINNATI, OHIO 45215 U.S.A.

The serial numbers and date of manufacture must be supplied when requesting replacement parts or optional accessories. For convenience, record the requested information below:

Base/Elect Cab S/N | | | | | | | | |

Powerhead S/N | | | | | | | | |

Console S/N | | | | | | | | |

Model Number | | | | | | | | | |

Date of Installation | | | / | | | / | | |

Installing Company _____

Address _____

Phone No. _____

FOREWORD

Congratulations on your purchase of the Liebel-Flarsheim Angiomat 6000 Digital Injection System. The Angiomat 6000 represents our effort to provide a quality product to support better health care throughout the world.

Regardless of how well a piece of equipment is designed misuse or abuse will deny its owner the expected safe, efficient, and quality service. Often, misuse or abuse occurs unintentionally, simply because the proper method of operating or servicing the equipment is unknown. We urge you to carefully read this manual before servicing the Angiomat 6000. Retain this manual for future reference.

NOTE TO INSTALLER: The Bauartzulassungs- Bescheinigung license is only valid with German language units.

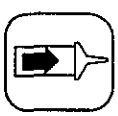
MEANINGS OF SYMBOLS USED IN THIS MANUAL

Please regard any message that follows the word Danger, Caution or Warning!

DANGER! *— Hazards which will result in severe personal injury or death.*
WARNING! *— Hazards which could result in personal injury.*
CAUTION! *— Hazards which could result in equipment or property damage.*

WARNING! *— Electical hazards which could result in personal injury.*

Non-Anesthetic proof



Injecting

Enabled (Injecting)

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1 GENERAL DESCRIPTION

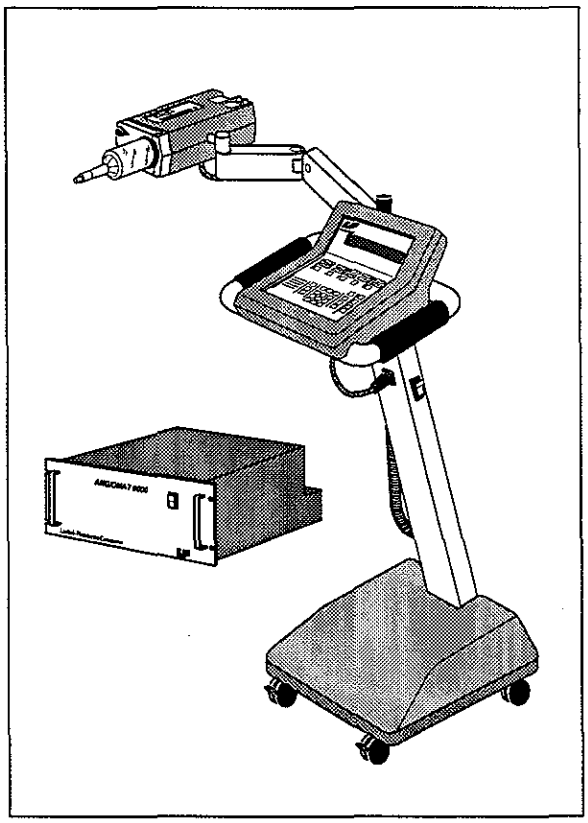


Figure 1-1
Liebel-Flarsheim Angiomat 6000 Digital Injection System

The Angiomat 6000 Injector is designed to inject a radiopaque contrast medium into the vascular system of humans and animals so the vascular system can be visualized by X-ray images. Each injection is accomplished with microprocessor control of the flow rate, volume, and timing—all provided by a motor-driven syringe mechanism.

This manual is intended to guide a service technician in the preventive maintenance and corrective repair of the Angiomat 6000 Injector. Included in this manual are: description of the injector, warranty of injector, installation and checkout procedures, description of operation, troubleshooting information, maintenance procedures, and pc board schematics to supplement the text. Operating procedures are covered in the Operator's Manual.

SPECIFICATIONS OF THE ANGIOMAT 6000 INJECTOR

Dimensions

Keyboard Console	14 W x 14 D x 7.5 H in (35.6 W x 35.6 D x 19 H cm)
Powerhead	6 W x 12.25 D x 4 H in (15 W x 31 D x 10 H cm)
Base	21 W x 21 D x 9 H in (53 W x 53 D x 23 H cm)
Electronics Cabinet	17 W x 17 D x 7 H in (43 W x 43 D x 17.8 H cm)

Weight

Powerhead	15 lbs (6.8 kg)
Keyboard Console	15 lbs (6.8 kg)
Base	50 lbs (23 kg)
Electronics Cabinet	18 lbs (8.1 kg)

Cord Lengths

Power Cord	15 ft (4.6 m)
Handswitch	7 ft (2.1 m) retracted
Powerhead	3 ft (0.9 m)
Console	1.7 ft (0.4 m)

Power Requirements

Standby	less than 1 A
Standard	115 VAC, 10 A, 50/60 Hz
Optional	230 VAC, 3.5 A, 50/60 Hz

Electrical Leakage

Chassis	less than 100 microamps
Isolated ECG Connections	less than 10 microamps

Fill Rate

Forward or reverse 3-25 ml/sec. Accelerates from zero to maximum within 3 seconds after pressing the Load/Unload keys in conjunction with the Fast key.

Syringe Heater

37 °C (98 °F) nominal

Syringes

Disposable	260 ml, 125 ml
Reusable	150 ml

Flow Rate

Range	Increment	Unit
1.0 — 9.9	0.1	ml/hr
10 — 99	1.0	ml/hr
0.01 — 0.99	0.01	ml/min
1.0 — 9.9	0.1	ml/min
10 — 99	1.0	ml/min
0.01 — 0.99	0.01	ml/sec
1.0 — 9.9	0.1	ml/sec
10 — 40	1.0	ml/sec

Transition Time

Range	Increment	Unit
0 — 0.99	0.01	sec
1.0 — 9.9	1.0	sec

Volume

125 ml Syringes

Range	Increment	Unit
0.1 —0.99	0.01	ml
1.0 — 9.9	0.1	ml
10 — 125	1.0	ml

150 ml Syringes

Range	Increment	Unit
0.1 —0.99	0.01	ml
1.0 — 9.9	0.1	ml
10 — 150	1.0	ml

260 ml Syringes

Range	Increment	Unit
0.1 —0.99	0.01	ml
1.0 — 9.9	0.1	ml
10 — 255	1.0	ml

Pressure Limit

Range	Increment	Unit
75 — 1200	1.0	PSI
500 — 8200	1.0	KPA
5 — 80	1.0	ATM
6 — 80	1.0	KG/CM^2

X-ray or Inject Delay

Range	Increment	Unit
.00 — .99	0.01	Sec
1.0 — 9.9	0.1	Sec
10 — 255	1.0	Sec

X-ray control: Pair of normally-open contacts rated to switch 1 A at 220 VAC.

Injection Duration

Range	Increment	Unit
.00 — .99	0.01	Sec
1.0 — 9.9	0.1	Sec
10 — 255	1.0	Sec

Pre-Programmed Injections

Up to 99 injections can be stored and recalled. (Memory capacity slightly less if equipped with ECG capability or if Multiphasic Injections are being stored.)

Software Version

Software version number will be displayed during power-up sequence.

DESCRIPTION OF THE ANGIOMAT 6000 INJECTOR

The major components of the Angiomat 6000 are shown in Figure 1-2.

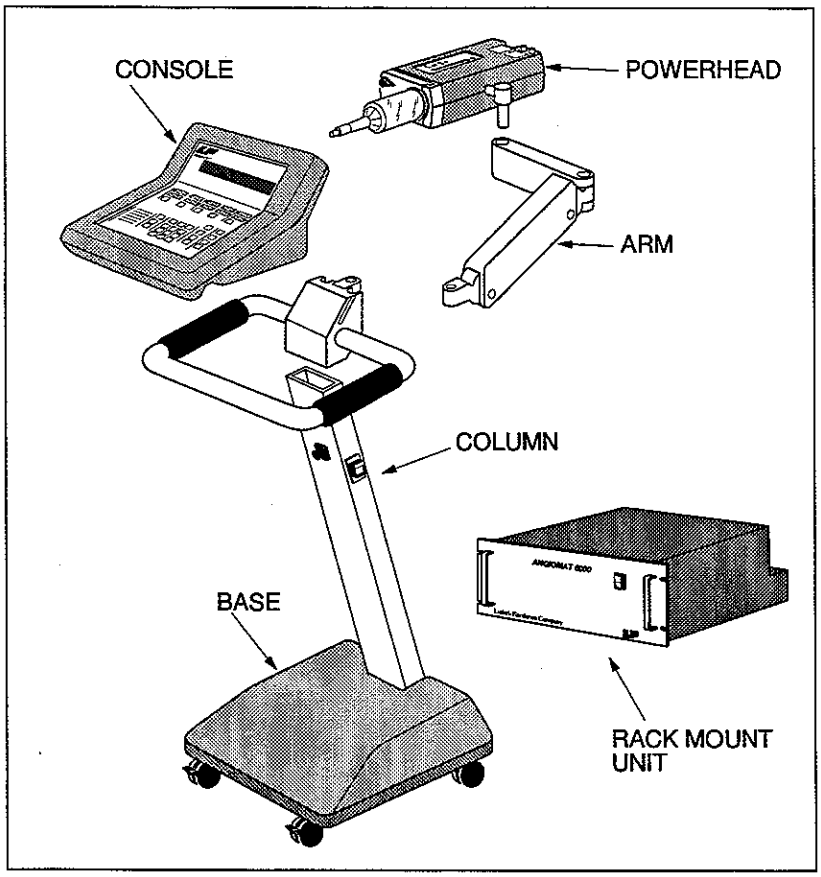


Figure 1-2
Angiomat 6000 Injector System Components

POWERHEAD

CAUTION!
Power must be off before connecting or disconnecting the Powerhead Cable. Connecting this cable after the Unit is powered may cause the Control Console to generate false error messages.

The powerhead (shown in Figure 1-3) houses the syringe mechanism; an electrical motor and gear train that drives the syringe ram; potentiometer and encoder for position and rate feedback to the control circuits; volume scale; loading controls; and a syringe heating system.

Communication circuits contained on pc boards in the powerhead allow data to be transmitted between the powerhead and control circuits. A single cable provides the interconnections between the powerhead and column/base.

Controls on the powerhead permit loading, unloading of syringes and scout injections. Indicators on the head advise the operator of the injector's status, syringe size and volume remaining in syringe.

Powerhead Controls and Indicators

The external features, controls and indicators of the powerhead are described below. Refer to Figure 1-3.

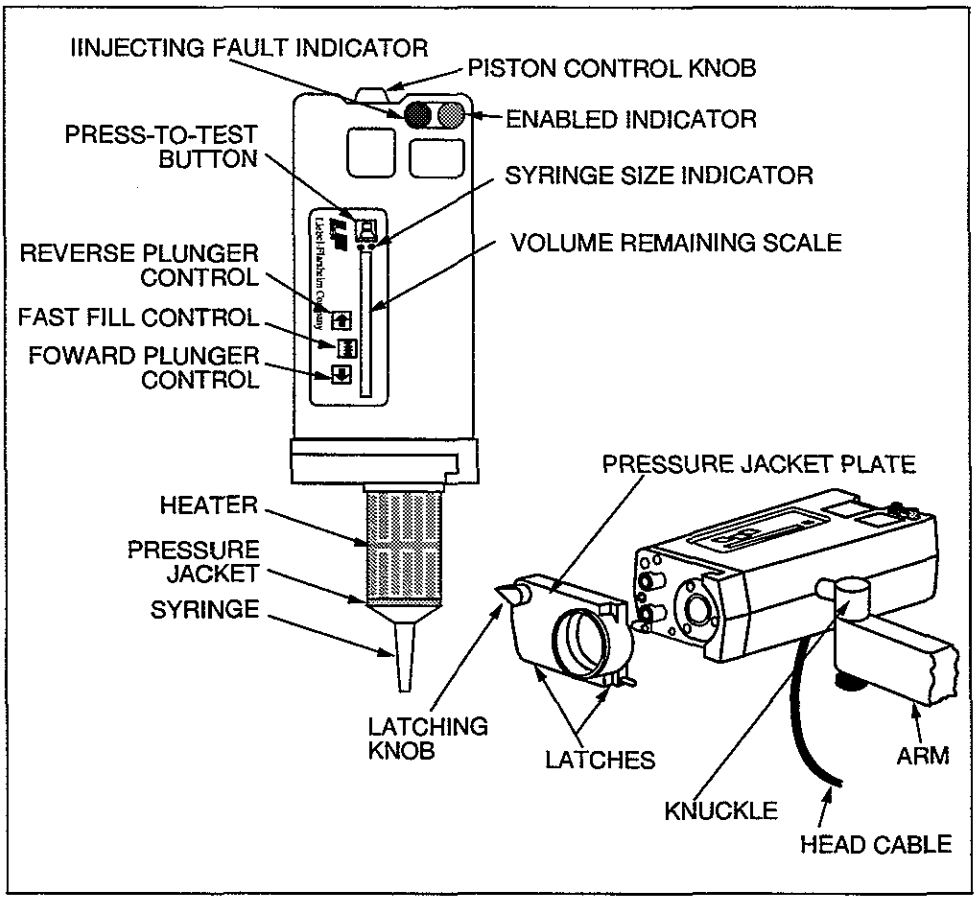


Figure 1-3
Powerhead

Syringe Assembly. The injector may be furnished with disposable or reusable syringes. Both types have a Luer fitting that connects to the catheter. When using disposable syringes, a pressure jacket holds the syringe and withstands injection pressure.

Heater. Maintains pre-warmed contrast medium in syringe at body temperature. The heater is not intended to heat contrast from room temperature to body temperature, but to maintain contrast that is already warm.

Press-to-Test key. This key allows the operator to periodically test the heater circuit for reliable operation. (See Chapter 7)

Pressure Jacket Plate. Three types are available — 125 ml, 150 ml or 260 ml. The head senses which size is being used and automatically selects the proper range of operation. The knob is shown in the unlatched position. A pair of latches on the bottom of the plate allow it to be removed and replaced.

Forward Plunger Control. This key moves the plunger forward, in preparation for loading the syringe, and to expel air. This function is activated when the forward button is pressed and the Fast Fill button is tapped. (By tapping the Fast Fill button repeatedly, the forward speed is increased)

Reverse Plunger Control. This key moves the plunger in reverse, to load the syringe with contrast medium. This function is activated when the reverse button is pressed and the Fast Fill button is tapped. (By tapping the Fast Fill button repeatedly the reverse speed is increased)

Fast Fill Control. This key increases the speed of the plunger to allow for faster filling of syringes.

Volume Remaining Scale. Shows the plunger position, indicating the volume remaining in the syringe. Read the scale corresponding to the syringe size installed.

Syringe Size Indicator. The appropriate lamp will glow to indicate the size of the currently installed pressure jacket.

Piston Control Knob. Moves the plunger forward by turning clockwise, reverse by turning counterclockwise.

Injecting/Fault Indicator. Indicator that lights to show when an injection is in progress. Flashes to show when there is a major injector fault.

Enabled Indicator. Indicator that lights when the injector is ready to inject. (Duplicates function of ENABLED indicator on keyboard console)

Knuckle. Permits rotating the head in two axes. Also permits the head to be removed from the arm by lifting the head straight up.

Arm. Permits easy positioning of the head, for adapting the injector system to a variety of table heights and room layouts.

Powerhead Cable. Provides all electrical connections between the head and column. Plug P1 mates with the connector labeled by the illustration of the Powerhead on the back of the column.

KEYBOARD CONSOLE

The keyboard console contains the majority of the operator's controls and indicators for the Angiomat 6000. It houses the main control panel and system display.

The keyboard console is enclosed in non-conductive plastic. Within it are the circuits for the control panel microprocessor and interface, system display converters and drivers, and serial communication circuits. The communication circuits allow data to be transmitted between the keyboard console and circuits contained in the base. The keyboard console cable provides all electrical connections between the keyboard console and column. Controls and indicators let the operator set up a variety of injection types and store those injections in protected memory.

The top portion of the control panel contains the System Display, which allows the Angiomat 6000 to display written messages. The balance of the control panel is divided into sections that allow the operator to enter injection parameters, to store and recall injection settings, and to control the injection.

WARNING!
Do not press on console or powerhead control panels with sharp or pointed items such as fingernails, ballpoint pens or pencils. Items of this type may puncture the panels and lead to a malfunction, resulting in unexpected plunger movement and patient injury.

The controls and indicators on the control panel are described below. The numbers in front of each item refer to Figure 1-4.

System Display

Two-line by 40-character display for messages and values. The second line is divided into fields referring to the controls just below the System Display.

Inject Delay, X-Ray Delay

Permit selection of one of these trigger modes. These controls determine the timing of the injector in relation to the X-ray exposure. The mode selected is shown by a lighted LED. The time selected is shown in the System Display directly above these controls. In the Special mode, the Select key may have a different function, defined in the System Display.

Inject Delay mode. The X-ray trigger is given when the injector is enabled and the start switch is pressed. The injection begins after the delay time shown in the System Display.

X-Ray Delay mode. The injector will start when enabled and the start switch is pressed. The X-Ray trigger is given after the delay time shown in the System Display.

Transition Time, Injection Duration

Transition Time. The time taken to achieve the selected flow rate from the start of the injection. If injection duration is selected, the flow rate will accelerate to the selected flow rate as quickly as possible.

Injection Duration. Total time of the injection.

The Select key permits selection of either transition time or injection duration, but not both. Only one mode can be selected for each injection. The mode selected is shown by a lighted LED. The time selected is shown in the system display directly above these controls. In the Special mode, the Select key may have a different function, defined in the System Display.

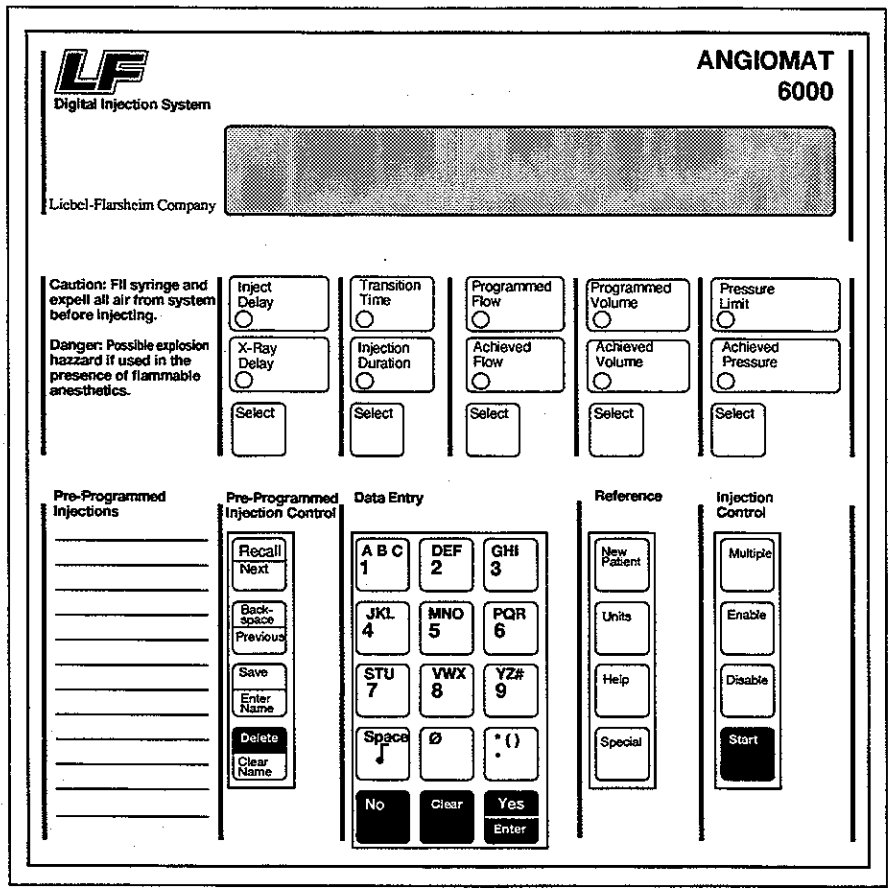


Figure 1-4
Control Panel

Programmed Flow, Achieved Flow

Permit the operator to program the flow rate when the Programmed Flow LED is lit. Display shows previous injection actual flow rate when ACHIEVED FLOW LED is lit.

Programmed Volume, Achieved Volume

Permit the operator to program the volume when the Programmed Volume LED is lit. Display shows previous injection delivered volume when ACHIEVED VOLUME LED is lit.

Pressure Limit, Achieved Pressure

Permit the operator to program the pressure when the Pressure Limit LED is lit. Display shows previous injection actual pressure when ACHIEVED PRESSURE LED is lit. If the PRESSURE LIMIT LED is lit on the post injection display, the Injector pressure has limited the Injection and the desired flow rate will not be achieved. To the right of the pressure, the System Display may indicate any of the pressure units: Pounds per Square Inch (PSI), Kilograms per Centimeter squared (KG/CM^2), Kilopascals (KPA), or Atmospheres (ATM). To change the pressure units, press the Units key after pressing the Select key.

Pre-Programmed Injection Control

With these controls the operator can store routine injection programs in the Angiomat 6000. Programs are retained in memory when the power turned off. These pre-programmed injections can be easily recalled for repeat setups.

Recall/Next. Press once to activate the recall mode. Then press repeatedly to step through each program in memory, or enter the number of the desired injection.

Backspace/Previous. If using the Data Entry keys, use the Backspace key to back up and delete one character on the System Display. If looking at the pre-programmed injections, press the Previous key to set up the previous injection.

Save/Enter Name. Press once to save any injection. Then, if desired, enter a name for the injection. The name can be any combination of alphanumerics, up to 16 characters, through the Data Entry keys. After entering the name, press the Enter Name key to store this name with the injection.

Delete/Clear Name. After recalling an injection, to erase it from memory, press the Delete button once; this message will appear on the System Display: READY TO DELETE, ARE YOU SURE? To delete the injection, press the Yes/Enter key. To save the injection (don't delete it), press the No key. The other function of the Delete/Clear Name key is to delete the name field from the current injection. This is operable when entering a name for the injection.

Data Entry

Keys 0 through 9. This keypad allows entry of numbers, letters, and symbols. To enter numbers, just press keys 0 through 9 and the decimal point (to the right of 0). Notice keys 1 through 9 also contain three color-coded letters on them. Also notice the three color keys along the bottom of the data entry keys: The red No key, blue Clear key, and green Yes/Enter key. To enter letters, press and hold one of the color keys, then press the letter key. For example, to enter A, press and hold red, then press 1. To enter B, press and hold blue, then press 1.

Musical Note Key. The musical note key turns the beeper on or off. With the beeper on, there will be a beep each time a key is pressed.

Space Key. The Space key enters a blank space at the current position on the System Display. To do this, press and hold the Space key with any color key.

Decimal Point. The decimal point (.) key enters a decimal point at the current position on the System Display. To enter the asterisk (*). and parentheses, press and hold a color key, then press this key.

Reference Keys

New Patient. Resets the running total patient volume to zero. (Reset also occurs when the injector is turned off.

Units. Changes the units for the flow rate or pressure, depending on which Select key was pressed just before the Units key. Press the Flow Rate key, then press the Units key to advance from ml/s to ml/m or ml/h. Press the Pressure Select key, then press the Units key to advance from PSI to KG/ CM^2, KPA, or ATM (BAR on international units).

Help. For most functions, provides messages on the System Display to help set up the injector. Simply press after selecting the setup function.

Special. Permits setting up special functions. Press the Special key and a menu of functions will appear on the System Display. Press the select key below the desired choice.

Injection Control

These keys allow selecting and viewing the injector's status, and starting the injection from the control panel. These keys provide these functions:

Multiple. Allows the injector to perform repeated injections as long as there is enough volume in the syringe. To set up the multiple mode, press the Multiple key, then press Enable. The green LED lights when the injector is in the Multiple mode.

Enable. Press to enable the injector. If the parameters have been set properly, the injector will begin its enable sequence (but it won't inject until after pressing the start switch). Syringes cannot be loaded in the enable mode; the forward and reverse load buttons don't function in the enable mode. The green LED lights when the injector is in the enable mode.

Disable. Press to disable the injector. This is the normal stand-by mode. This mode allows loading and parameter setup, but prevents an injection.

Start. Starts an injection from the control panel. Press this key simultaneously with the YES/ENTER key. The START key must be held down throughout the injection in the ml/s mode. If the START key is released the Injection will stop. In flow rates of 5 ml/s or slower the keys will latch. The green LED beside the key lights during an injection.

COLUMN AND BASE/ RACK MOUNT

The base/electronics cabinet contains the majority of the electronics for the Angiomat 6000. It houses most of the circuit boards and the main system power supply. Within the base are the circuits for the main microprocessor, I/O converters and interfaces, servo amplifier, and serial communications circuits.

The communications circuits allow data to be transmitted between the base and the head, and between the base and the keyboard console. The base and column contain the connectors for the powerhead, keyboard console, and for other external wiring.

Power Switch and Circuit Breaker

This lighted rocker switch turns the Angiomat 6000 on and off. To turn power on, press the top half of the switch. To turn power off, press the bottom half. The switch lights when the injector is on. This switch also contains a circuit breaker to protect the Angiomat 6000. If the circuit breaker trips, the switch will turn off. To reset, press the top half, in the same manner as turning on the power.

NOTE: 230 VAC MODELS ONLY
After turning off the injector, wait 10-15 seconds before turning back on. If the injector is turned on without waiting, the internal circuits may latch. If this happens, just turn off the injector and wait these few seconds, then turn it on again.

Refer to Figure 1-5 and Figure 1-6.

J1, Powerhead Connector

Connects the column and base to the head. Extension cables are available for remote installations. Contact your local distributor for details.

J2, Keyboard Console Connector

Connects the column and base to the keyboard console. Extension cables are available for remote installations.

Power Cord

Power requirements are given in the Angiomat 6000 Specifications section, Chapter 1. If your unit uses an electronics cabinet, an IEC input module may be in place of the Power cord shown in Figure 1-6.

ECG Input (Part of ECG Option)

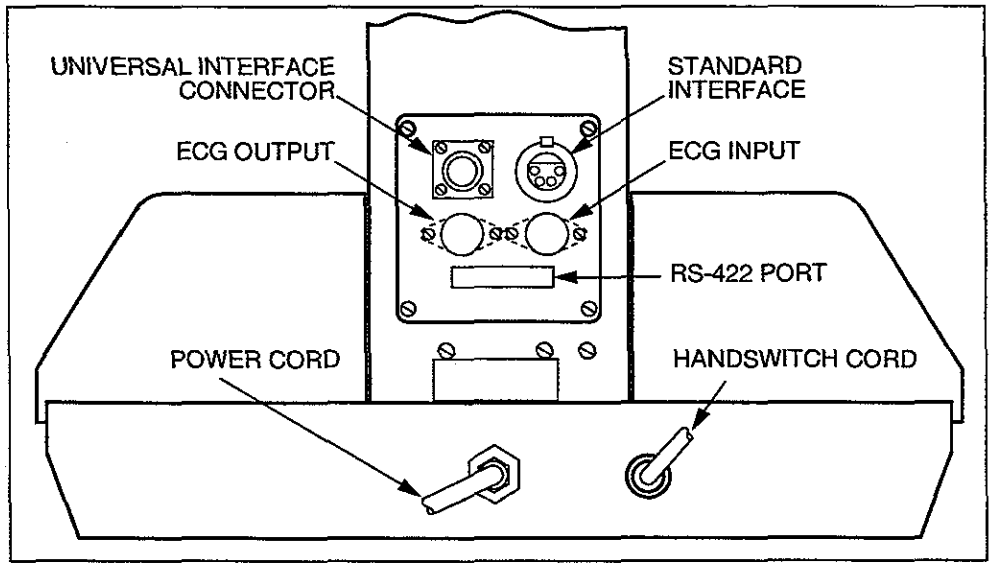
A 5-pin DIN receptacle, flange-type connector accepts signals from ECG monitors and pre-amps.

ECG Output (Part of ECG Option)

A 4-pin DIN receptacle, flange-type connector provides feedback signals to be used with an ECG monitor as the Angiomat 6000 performs ECG-triggered injections.

Remote Connector (Optional)

This 25-pin D-Shell connector allows the unit to interface with equipment using the RS-422 communications standard.



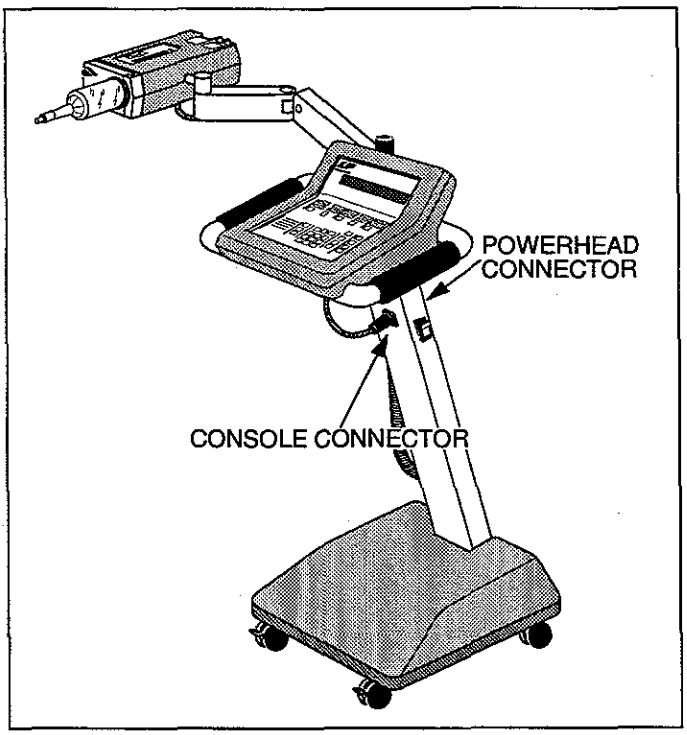


Figure 1-5
External Equipment/Control Connections
(Located on Support Column)

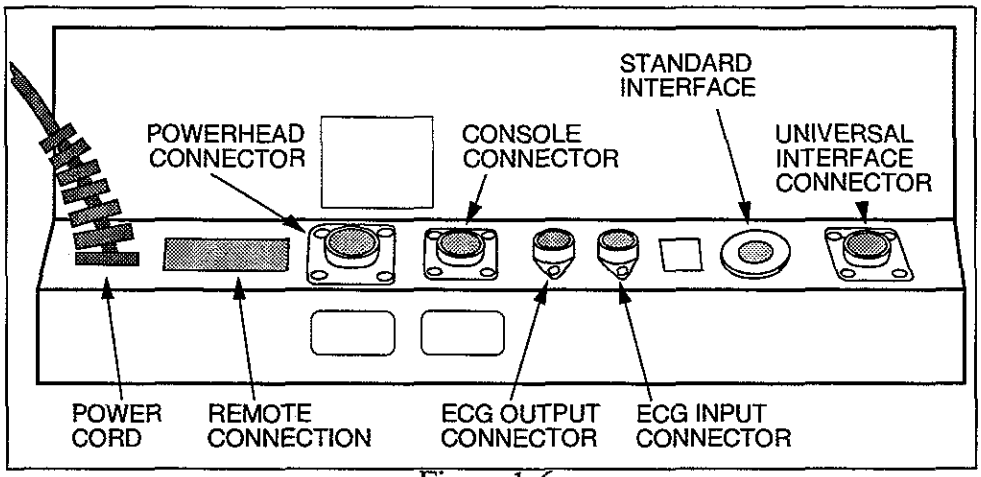


Figure 1-6
External Equipment/Control Connections
(Located on Rear of Rack Mount Cabinet)

WARNING!
If the Injector is wired to a redundant external start circuit, the operator does not have full control of the Injector with the standard start switch. The start switch may be used to start the Injector as normal, but once the external start contacts are closed, the operator's start switch alone cannot stop the Injector. To stop the injection, the start circuit must be completely open. All start switches and external start contacts must open. The injection can also be stopped by pressing the disable key on the Injector's control panel.

Handswitch Cord

Connection at the base for the standard handswitch provided with every Angiomat 6000 pedestal version. The handswitch must be pressed for the duration of the injection.

J5, Standard Interface

This 4-pin connector interfaces the injector to an external start switch. The mating connector is Switchcraft A4ML or equivalent.

J4, Universal Interface Connector

This 10-pin connector interfaces the injector to an external start and film changer. The mating connector is Hirose JR16PK-10P or equivalent.

2 INSTALLATION

GENERAL

This Chapter details installation of the Angiomat 6000, addressing topics in the following sequence:

- receiving inspection
- assembly and
- interfacing of the injector with an imaging device.

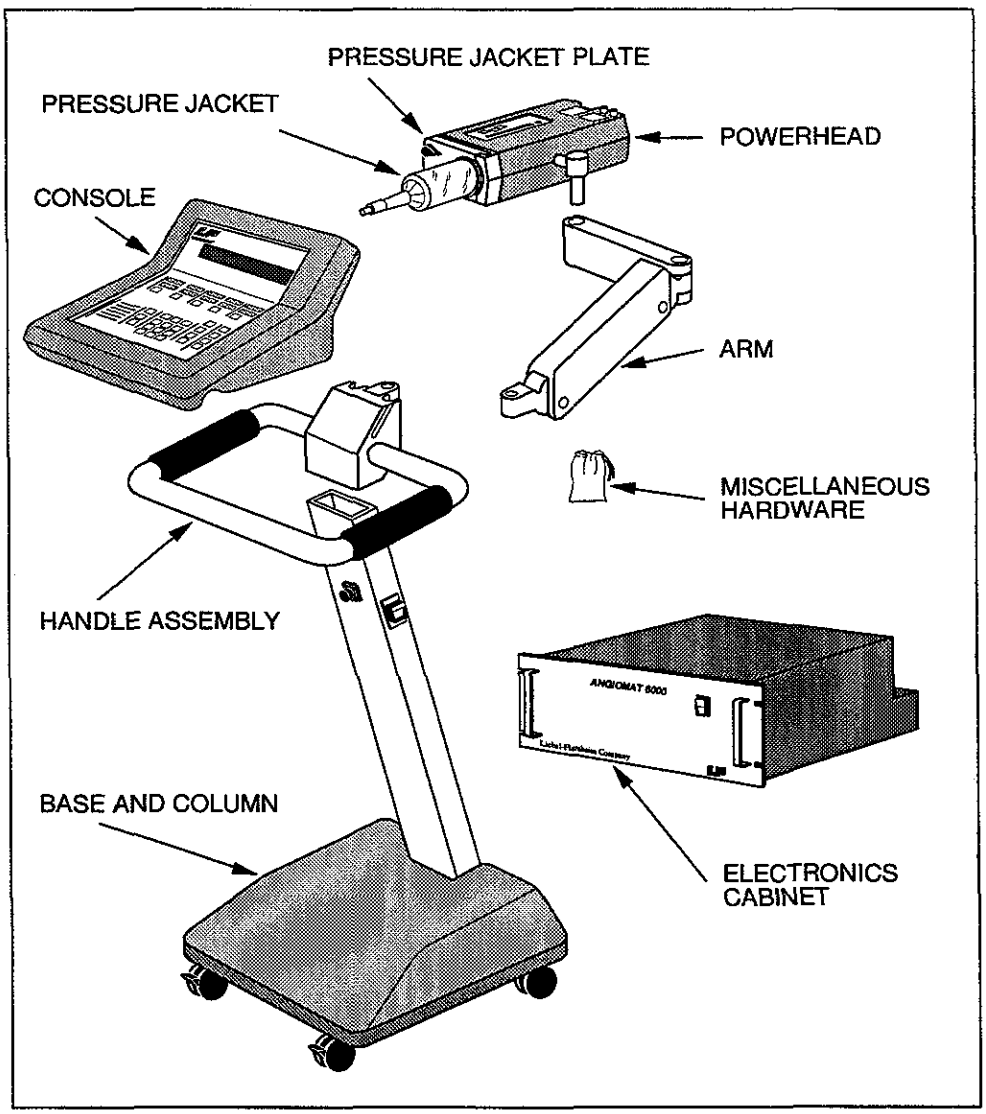


Figure 2-1
System Components and Assembly

RECEIVING INSPECTION

The Angiomat 6000 Injector should be subjected to inspection immediately upon arrival at its shipping destination.

CAUTION!
Electronic components, contained within the Angiomat 6000 Injector, may be damaged by impact. Exercise caution while handling the Angiomat 6000 Injector; avoid dropping the unit or subjecting it to other physical shock.

INSPECTION FOR DAMAGE

All Liebel-Flarsheim products are thoroughly tested prior to shipment and leave our facility in perfect operating condition. If the shipment has been received in undamaged condition and in its entirety, it may be moved either to the installation site or to a temporary storage facility. To determine whether damage may have occurred to the injector during shipment, inspection personnel at the shipping destination should inspect for the following possible types of damage:

In-Transit Damage

In-transit damage is apparent even before the shipping container has been opened and may be indicated by such damage to the shipping container as crushing, cutting or puncture. If such signs are obvious upon receipt, do not accept the shipment until the carrier's agent has noted the extent of damage on the freight bill.

You can refuse to accept damaged goods.

Concealed Damage

Concealed damage is not apparent until the unit has been unpacked. Immediately upon discovery of such damage, and within fifteen days of receipt of the shipment, the carrier's agent should be contacted and asked to provide a standard form by which such damage is reported. Filing this report is the legal right of the recipient.

Processing of Damage Claims

If damage has occurred to the Angiomat 6000 during shipment and if the above procedures have been followed, then Liebel-Flarsheim will assist in the establishment of a claim against the carrier.

Goods returned for credit, exchange or repair will not be accepted by Liebel-Flarsheim unless written authorization has been issued by Liebel-Flarsheim.

INSPECTION FOR COMPLETE SHIPMENT

Unpack the system and verify receipt of all components listed for the applicable injector configuration. See Figure 2-1.

Pedestal Injector

Verify receipt of the following undamaged components:

- ❑ Arm
- ❑ Base and Column Assembly
- ❑ Console
- ❑ Handle Assembly
- ❑ Powerhead
- ❑ Pressure Jacket
- ❑ Pressure Jacket Plate
- ❑ Miscellaneous Hardware

Rack-Mount Injector

Verify receipt of the following undamaged components:

- ❑ Console
- ❑ Electronics Cabinet
- ❑ Powerhead
- ❑ Pressure Jacket
- ❑ Pressure Jacket Plate

Cables

- ❑ Console Extension Cable: Part No. _____ (See Tables 2-1 and 2-2)
- ❑ Powerhead Extension Cable: Part No. _____ (see Tables 2-3 and 2-4)

- ❑ Miscellaneous Hardware

Discrepancies

Report any discrepancies to:

the Liebel-Flarsheim Company
Order Management
2111 East Galbraith Road
Cincinnati, Ohio 45215
1-800-877-0611

SITE INSTALLATION TIPS

To ensure the highest operating reliability of the Angiomat 6000 injector, the following considerations should be heeded.

- To minimize any possible electrical interference between the injector and companion imaging system,, the injector's electronics cabinet and the console should be place as far away as possible from the x-ray generator or and x-ray control cabinets to avoid radiated coupling to the injector. While the injector has been provided with adequate shielding, x-ray generators can omit a considerable amount of interfering radiation, especially during tube arcs.
- Electrically isolate the injector power ground to minimize any effects of conducted emissions from the imaging source.
- Locate the injector's electronics cabinet away from any source of possible contrast contamination. Wet contrast, especially ionic, spilled or splashed on electronics circuits can cause unpredictable or erratic operation of the injector.
- Locate the injector cables away from all high power/high voltage power mains image system cables. Do not place in troughs together or run in parallel on the floor. Loops of unused cables can act as pickup coils to unwanted signals and noise. If cable must meet, try to limit to right angle crossings. Cable cross cable coupling can be a major source of unwanted interference.
- Verify the electrical integrity of shields on cables, connectors, and mating covers. If custom cutting cables, make sure the shields have been reestablished. Loss of a shield on one end of a cable, even 2-3", can cut the effectivity of the entire shield by up to 95%. Avoid pigtail shields termination if possible. Optimum shields are coupled 360° around a metal connector.
- Ensure that the power source for the injector is well within the specified voltage range of the injector (110 VAC—115 VAC/ 220VAC—230VAC). Low voltage or brownouts can change the operating performance of the unit.

ASSEMBLY OF A PEDESTAL INJECTOR

Install Handle Assembly

1. Position the handle assembly in accordance with Figure 2-2. Lower the positioning block, projecting downward from the handle assembly yoke, into the top of the column in the base and column assembly. Align two clearance holes, penetrating the front of the column, with two tapped holes in the positioning block.
2. Select two 1/4-20 x 5/8 flat head socket cap screws from the miscellaneous hardware. Apply Loctite® to both screws and install them through the clearance holes in the column and into the tapped holes in the handle assembly. Verify that both screws are secure.

Install the Console to the Handle Assembly

1. Position the console in accordance with Figure 2-1.
2. Slip the mounting bracket, at the rear of the console, into mating grooves in the handle assembly.
3. Slide the console down until it rests on the handle assembly.

Install the Arm on the Handle Assembly

1. Locate the yoke at the rear of the handle assembly. See Figure 2-3. Remove the locking set screw from the yoke; retain this screw. Tap the clevis pin up and out of the yoke using a drift pin and hammer.
2. Position the arm as illustrated in Figure 2-3. Select two plastic washers (1/2 I.D. x 1-1/2 O.D.) from the miscellaneous hardware; align one washer above and one below the narrow mounting hinge at one end of the arm. Fit the mounting hinge into the yoke.
3. Insert the clevis pin down through the top of the yoke, through the upper plastic washer, through the arm, through the lower plastic washer and into the bottom of the yoke. Secure the clevis pin by re-inserting and tightening the locking set screw.

Install the Powerhead on the Arm:

1. Unscrew the knob assembly from the powerhead pivot assembly.
2. Lower the powerhead pivot assembly into the flanged bushing at the free end of the arm.
3. Insert the knob assembly up through the flanged bushing and into the powerhead pivot assembly; tighten the knob assembly as desired. The knob assembly serves as a friction brake on rotation of the powerhead pivot assembly. Tightening the knob assembly will increase resistance to rotation of the powerhead. Loosening the knob assembly will decrease resistance to rotation of the powerhead.

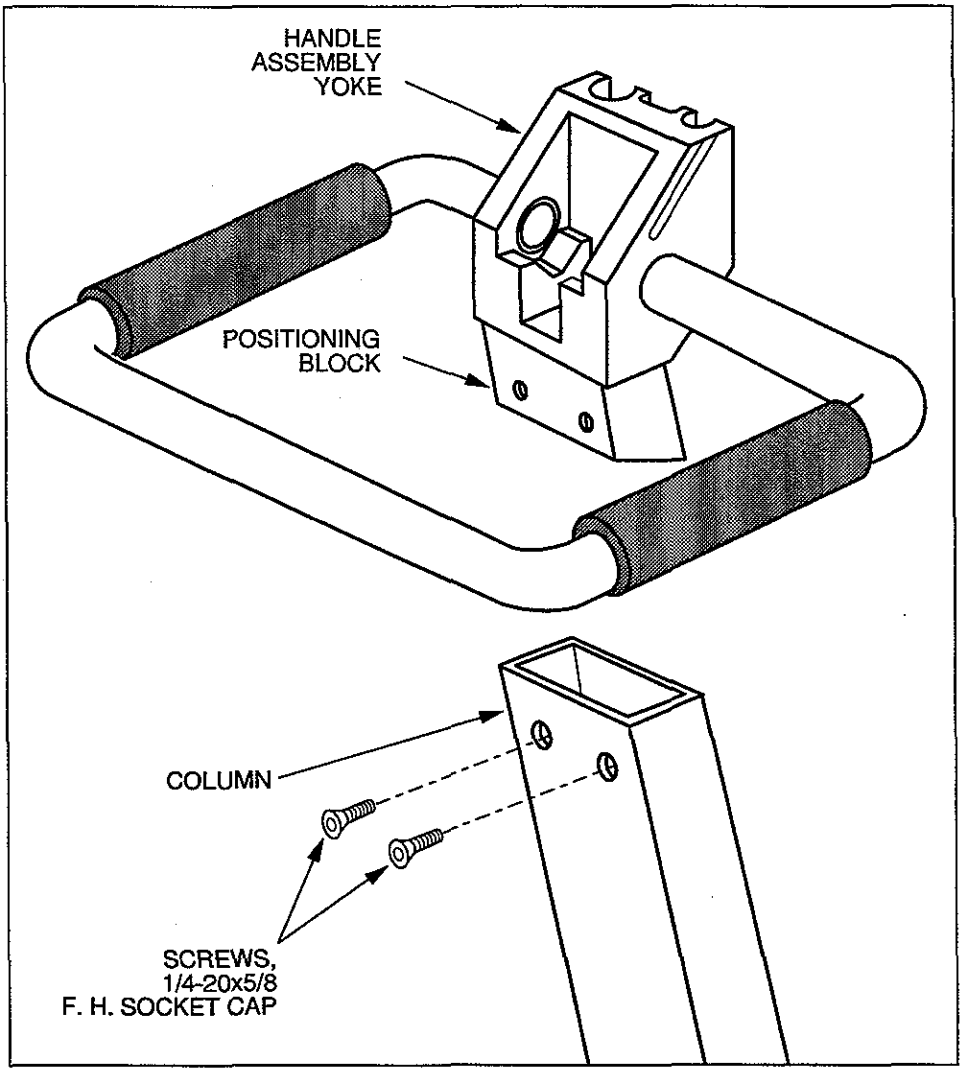


Figure 2-2
Installation of the Handle Assembly to the Pedestal Column

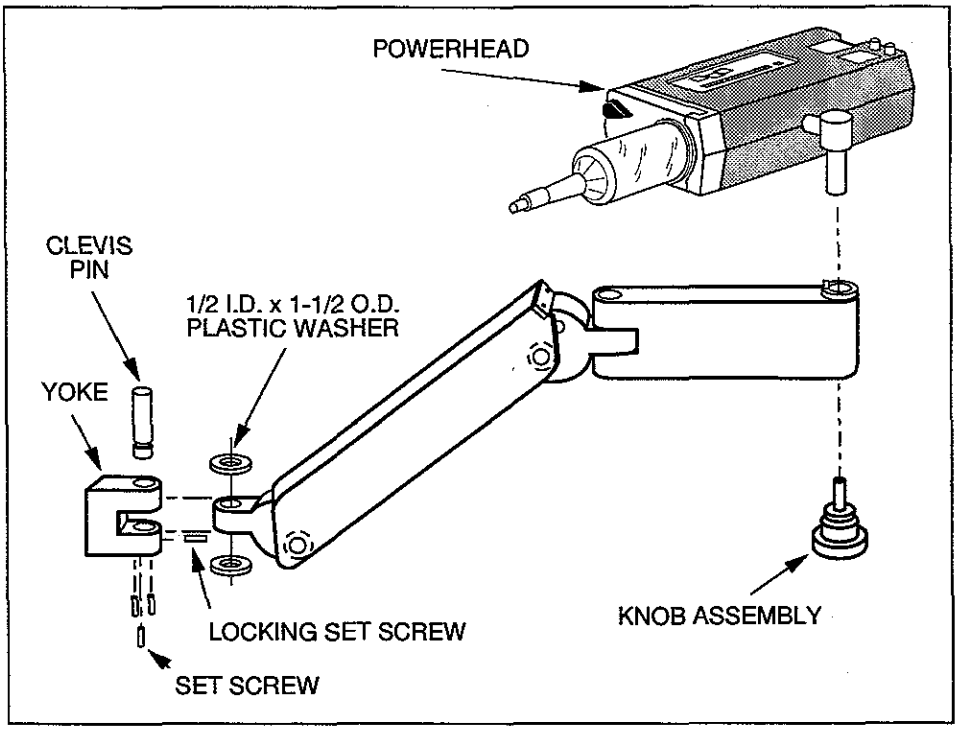


Figure 2-3
Installation of the Arm on the Handle Assembly

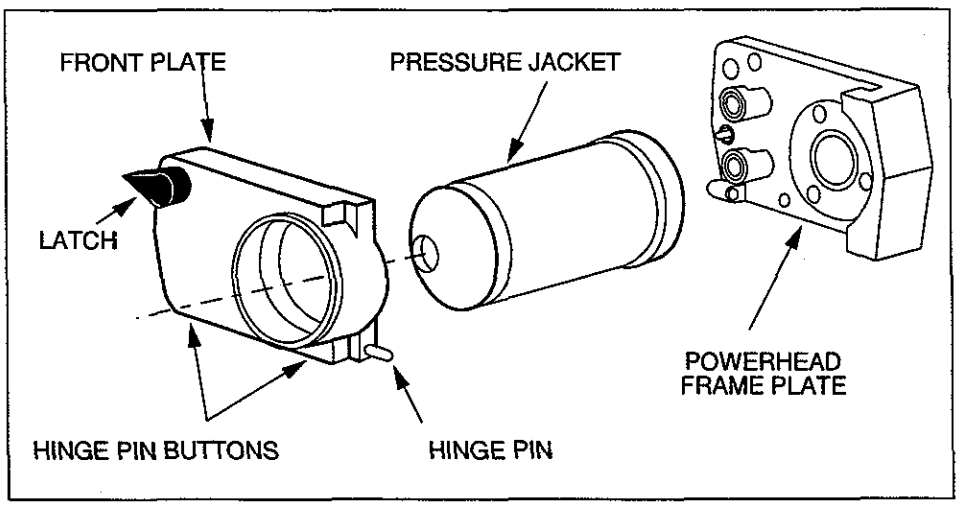


Figure 2-4
Pressure Jacket and Front Plate

Install the Pressure Jacket in the Front Plate

1. Align notches in the jacket with three retaining screws; insert the pressure jacket fully into the front plate. See Figure 2-4.
2. Rotate the pressure jacket counterclockwise (if viewed from behind the plate) until the pressure jacket flange engages the retaining screws and locks in place. See Figure 2-5.

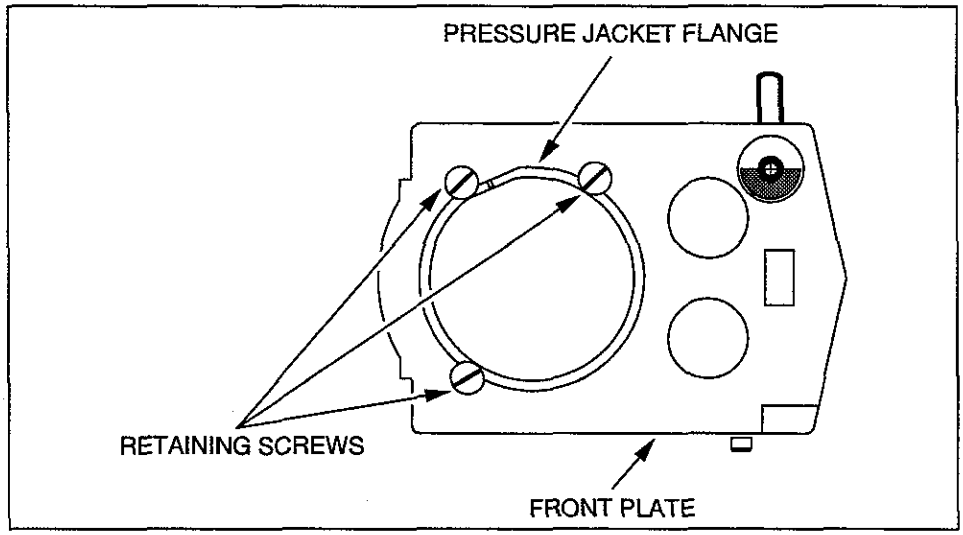


Figure 2-5
Location of Retaining Screws on Front Plate

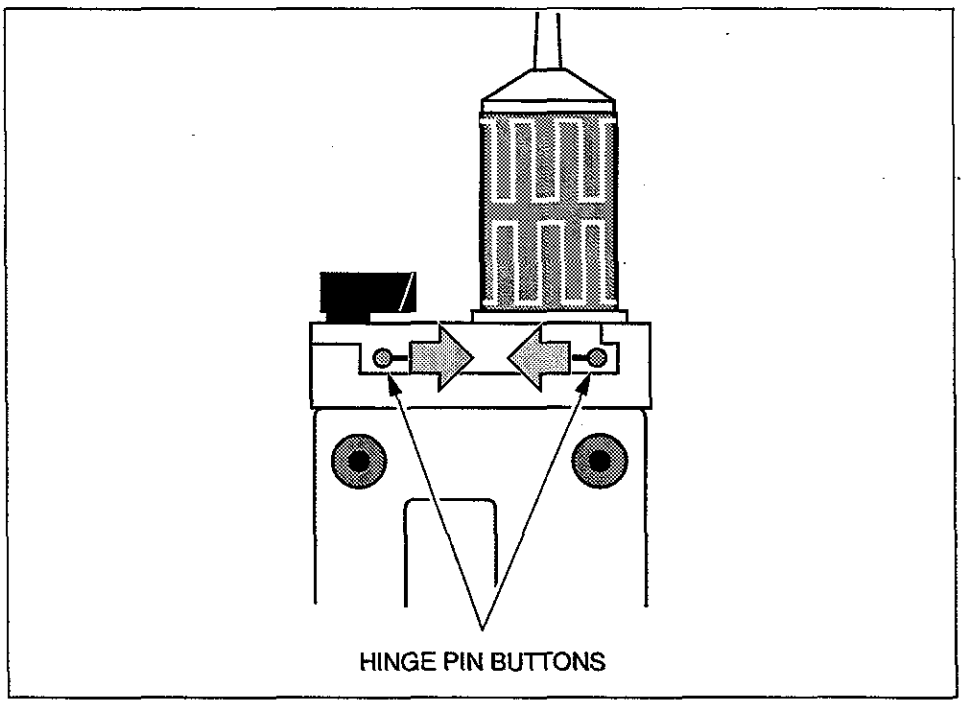


Figure 2-6
Location of Hinge Pin Buttons at Bottom of Front Plate

Mount the Front Plate to the Powerhead

1. Retract both hinge pins into the front plate by squeezing the hinge pin buttons together. See Figure 2-6.
2. Place the front plate against the powerhead frame plate. Release both hinge pin buttons, allowing the hinge pins to lock into mating receptacles in the powerhead frame plate.

NOTE: Power must be "OFF" before connecting either the console or powerhead cable. Connecting either cable after the unit is powered may cause the console to generate false error messages.

Connect the Console Cable/Powerhead Cable

1. Locate receptacle J2 on the front of the injector column. Carefully align the pins on the console cable plug with receptacle J2; insert the plug into the receptacle. See Figure 2-7.
2. Locate receptacle J1 on the rear of the injector column. Carefully align the pins on the powerhead cable plug with receptacle J1; insert the plug into the receptacle. See Figure 2-7.
3. Secure the plugs by screwing their collars onto the mating threads.

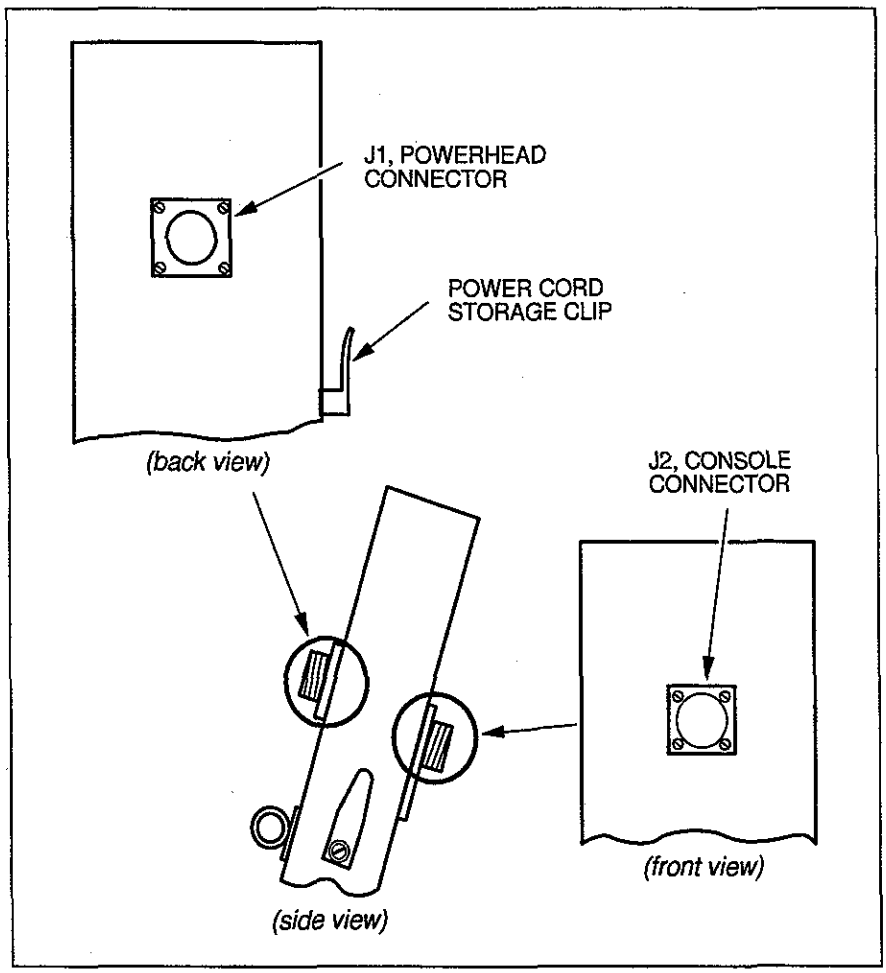


Figure 2-7
Location of Receptacles J1 and J2 on the Injector Column

INSTALLATION OF A RACK MOUNT INJECTOR

Components of the rack-mounted Angiomat 6000 Injection System may be arranged in conformance with the spatial characteristics of the installation site.

The following *optional* equipment may be used in the configuration of a rack-mounted Angiomat system.

EXTENSION CABLES

Extension cables are required to connect either a remotely-placed console or powerhead to the electronics cabinet.

Console Extension Cables

Console extension cables connect a remotely-placed console to the Angiomat 6000 electronics cabinet. Refer to Tables 2-1 and 2-2 for standard lengths in which console extension cables can be ordered.
NOTE: The maximum cable length to connect the Console to the Electronics Cabinet is 80 feet (24.38 m).

Length (feet)	*Length (meters)*	*Cable Connector Both Ends*	*Cable Connector / Female Flange*
5	1.5	600125	600126
10	3.0	600115	600159
20	6.1	600116	600160
30	9.1	600117	600161
40	12.2	600118	600162
50	15.3	600119	600163
60	18.3	600185	600190
70	21.3	600186	600191
80	24.4	600187	600192
90	27.4	600188	600193
100	30.5	600189	600194

Table 2-1
Console Extension Cables: 115 VAC

Length (feet)	Length (meters)	Cable Connector Both Ends	Cable Connector / Female Flange
5	1.5	600147	600238
10	3.0	600148	600239
20	6.1	600149	600240
30	9.1	600217	600241
40	12.2	600218	600242
50	15.3	600219	600243
60	18.3	600233	600244
70	21.3	600234	600245
80	24.4	600235	600246
90	27.4	600236	600247
100	30.5	600237	600248

Table 2-2
Console Extension Cables: 230 VAC

Powerhead Extension Cables

Powerhead extension cables connect a remotely-placed powerhead to the Angiomat 6000 electronics cabinet. Refer to Tables 2-3 and 2-4 for standard lengths in which powerhead extension cables can be ordered. **NOTE:** The maximum cable length to connect the Powerhead to the Electronics Cabinet is 100 feet (30.48 m).

Length (feet)	Length (meters)	Cable Connector Both Ends	Cable Connector / Female Flange
5	1.5	600109	600124
10	3.0	600110	600164
20	6.1	600111	600165
30	9.1	600112	600166
40	12.2	600113	600167
50	15.3	600114	600168
60	18.3	600195	600200
70	21.3	600196	600201
80	24.4	600197	600202
90	27.4	600198	600203
100	30.5	600199	600204

Table 2-3
Powerhead Extension Cables: 115 VAC

Length (feet)	Length (meters)	Cable Connector Both Ends	Cable Connector / Female Flange
5	1.5	600231	600229
10	3.0	600232	600230
20	6.1	600084	600087
40	12.2	600085	600088
80	24.4	600086	600089

Table 2-4
Powerhead Extension Cables: 230 VAC

SUSPENSION SYSTEMS

Suspension Systems allow the Angiomat powerhead to be flexibly mounted at a distance from the electronics cabinet. Separate instructions for the Suspension System are suppled with each Suspension System shipment.

Cable Entrance Trim Kit, Part No. 241853

The Cable Entrance Trim Kit may be used in conjunction with a ceiling-mounted suspension system. When installed through either suspended ceiling panels or a construction of similar thickness, the kit creates a channel through which power and control cables may be routed; the kit's trim plate provides the installation with a finished appearance. The Trim Kit does not provide strain relief. Additional provisions must be made to prevent damage to the powerhead cable. Refer to Figure 2-9. Separate instructions for the Cable Entrance Trim Kit, is supplied with each Cable Entrance Trim Kit shipment.

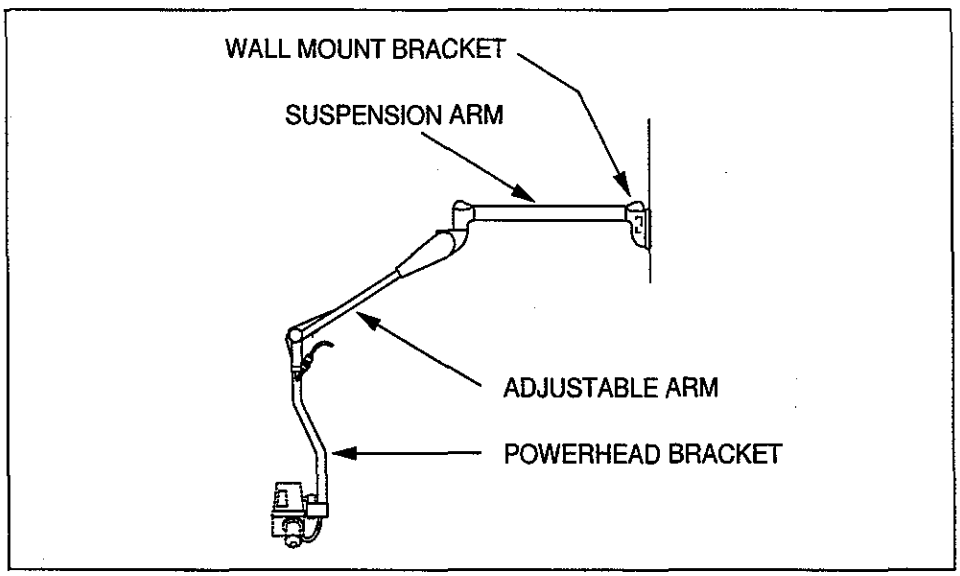


Figure 2-8
Wall-Mounted Powerhead Arm and Bracket Assembly

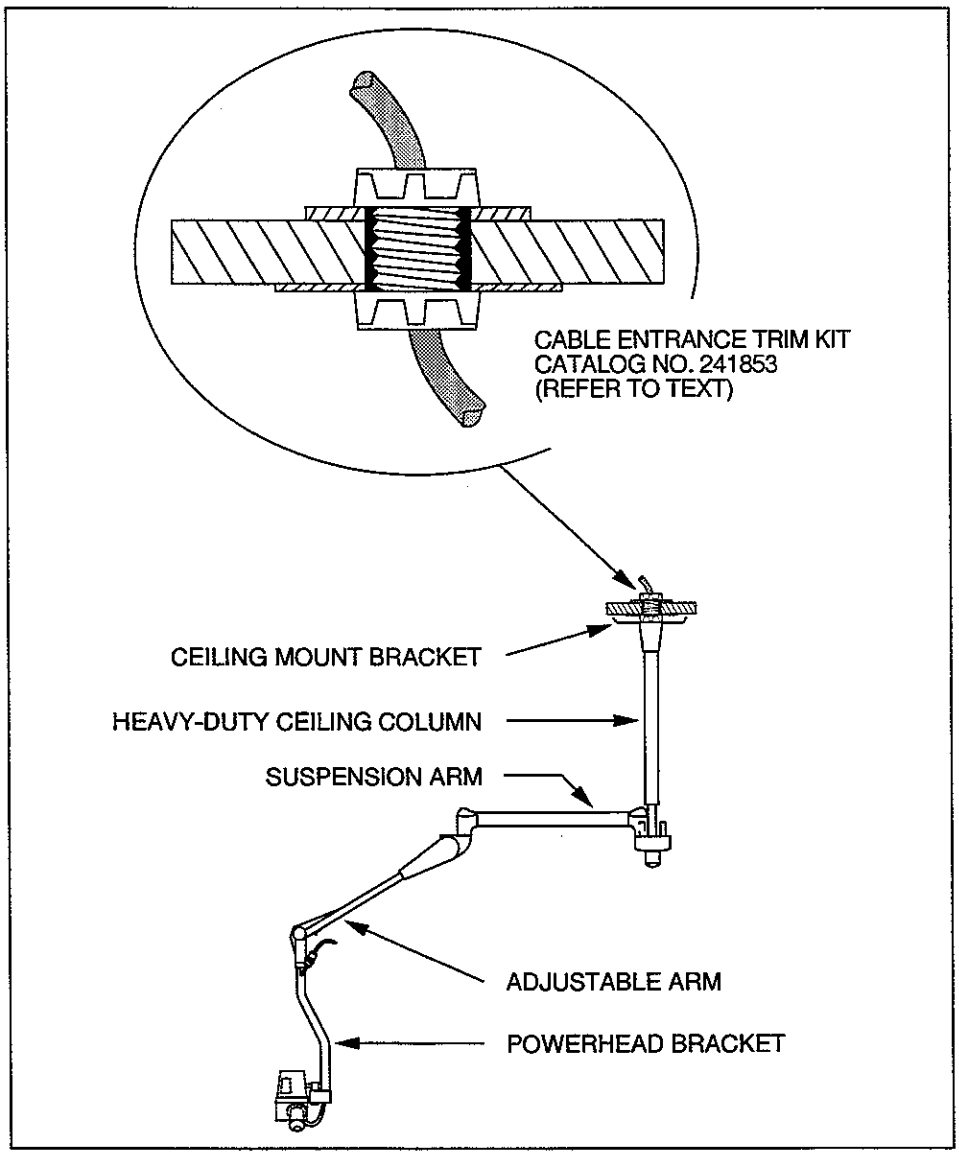


Figure 2-9
Ceiling-Mounted Powerhead Arm and Bracket Assembly

CONSOLE WALL-MOUNTING BRACKET CATALOG NO. 600106

The Console Wall-Mounting Kit allows the Angiomat 6000 console to be securely mounted at a distance from the unit electronics cabinet.

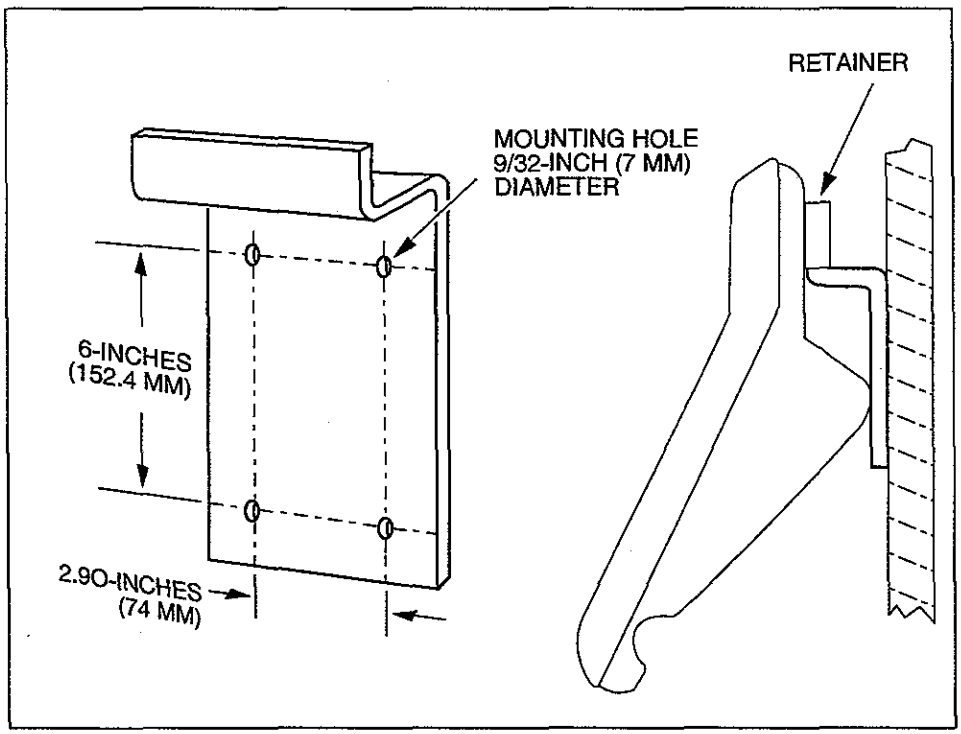


Figure 2-10
Console Wall-Mounting Bracket

Required Supplies

The following supplies must be procured before installation of the console wall-mounting bracket is attempted:

- a drill
- a 1/4-inch drill bit
- an appropriate console extension cable and
- 4 each fasteners and anchors, used in securing the mounting bracket.

The Anchoring System

The selection of suitable anchors to secure the Wall-Mounted Bracket is of extreme importance; the selection of unsuitable anchors could allow the Bracket to pull free, possibly causing injury to personnel or damage to equipment. When selecting anchors and mounting bolts:

- Verify that the anchoring device conforms to all applicable building codes and standards.

- Verify the compatibility of the anchor and bolt materials using a Galvanic Corrosion Chart. Failure to consider the Galvanic Corrosion Effect could result in the selection of fasteners that will fail if exposed to a moist environment.

Installation of the Console Wall-Mounting Bracket

1. Position the Bracket at the desired location. Using the mounting holes as a template, scribe the locations at which anchoring devices will be installed. See Figure 2-10.
2. Drill holes into the wall at appropriate points; hole depth and diameter shall be as specified by the manufacturer of the anchors.
3. Install wall anchors in accordance with directions provided by the manufacturer of those anchors.
4. A steel retainer, located on back of the Angiomat 6000 console, slips around the Wall-Mounting Bracket, as illustrated in Figure 2-10. To mount the console to the wall, slip the retainer over the wall-mounting bracket.

ADJUSTABLE SHELF BRACKET ASSEMBLY CATALOG NO. 601634

The Adjustable Shelf Bracket Assembly allows the Angiomat 6000 console to be securely mounted to either a vertical or horizontal surface while providing the option of angular adjustment.

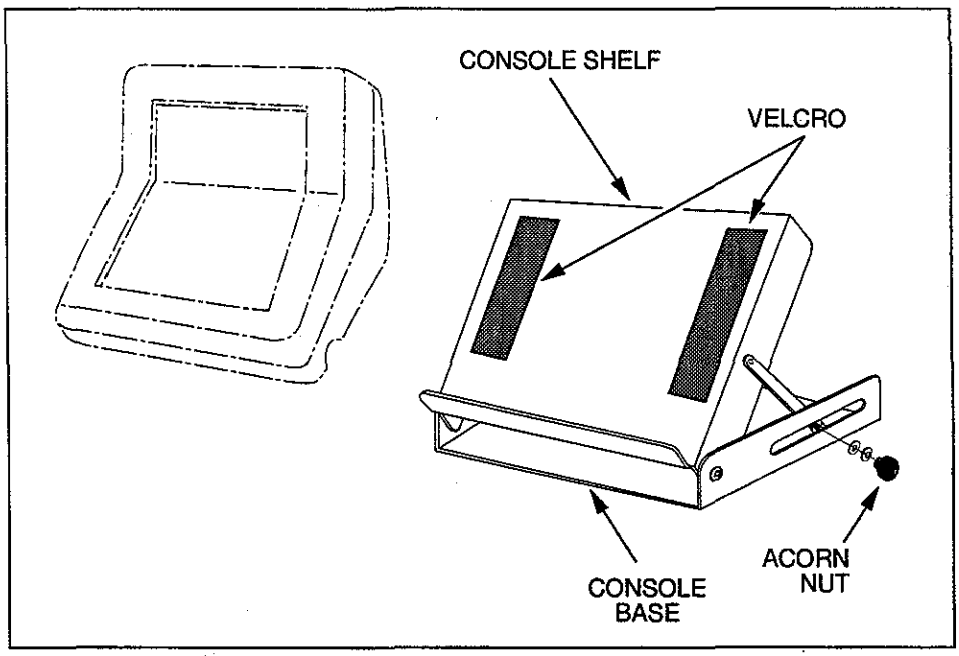


Figure 2-11
Adjustable Shelf Bracket Assembly
Oriented for Horizontal Mounting

Required Supplies

- a 7/16-inch wrench
- two 1/4-inch anchors and
- an appropriate console extension cable.

The Anchoring System

The selection of suitable anchors to secure the bracket assembly is of paramount importance; the selection of unsuitable anchors could allow the bracket to pull free, possibly causing damage to the equipment. When selecting anchors and mounting bolts:

- Verify that the anchoring device conforms to all applicable building codes and standards.
- Verify the compatibility of the anchor and bolt materials using a Galvanic Corrosion Chart. Failure to consider the Galvanic Corrosion Effect could result in the selection of fasteners that will fail if exposed to a moist environment.

Vertical Mounting of the Bracket Assembly

1. Position the shelf base in the vertical plane. Using a 7/16-inch wrench, loosen the 1/4-20x7/16 acorn nut on each side of the assembly. Lower the shelf to a position approximately perpendicular to the shelf base. See Figure 2-11.
2. Position the assembly and use its mounting holes as a template to scribe the locations at which anchors will be installed.
3. Install wall anchors in accordance with directions provided by the manufacturer of those anchors.
4. Fit the mounting holes over the wall anchors, lower the bracket assembly into position and tighten the anchors securely.
5. Position the shelf in the horizontal plane and tighten both acorn nuts to secure its position.

Horizontal Mounting of the Bracket Assembly

1. Use a 7/16-inch wrench to loosen the 1/4-20x7/16 acorn nut on each side of the assembly. Raise the shelf to a position approximately perpendicular to the shelf base. See Figure 2-11.
2. Position the assembly and use its mounting holes as a template to scribe the locations at which anchors will be installed.
3. Install anchors in accordance with instructions provided by the manufacturer of those anchors.
4. Position the bracket assembly and secure it by tightening the anchors.
5. Close the assembly, lowering the shelf to the horizontal plane.

Mounting the Console to the Bracket Assembly

1. Disconnect the Angiomat console cable at the electronics cabinet.
2. Remove the protective backing from the two exposed Velcro strips and locate the console conveniently on the upper surface of the shelf.
3. Press the Angiomat console firmly on the exposed surface of the Velcro pads; each pad is impregnated with adhesive, causing it to adhere to the bottom of the console. Allow the adhesive to cure for twenty-four hours.
4. Connect the console cable to the electronics cabinet using an appropriate console extension cable.

Adjusting the Angle of the Bracket Assembly

1. Use a 7/16-inch wrench to loosen the acorn nut on each side of the assembly while securely supporting the bracket shelf.
2. Carefully change the angle at which the shelf contacts its base.
3. Securely tighten both acorn nuts.

TABLE MOUNT KIT
CATALOG NO. 600150

The Table Mount Kit provides a flexible mount for the Angiomat 6000 powerhead and is compatible with any rail that is 1-inch high and 1/2-inch thick.

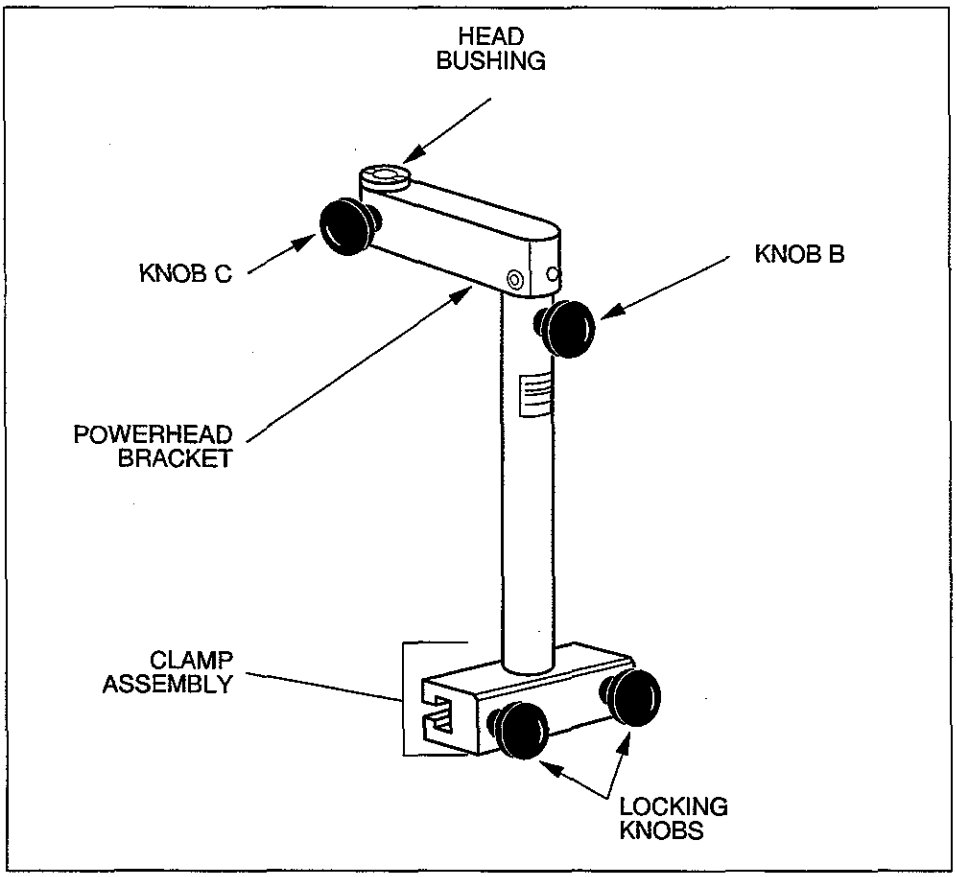


Figure 2-12
Table Mount Kit

Installation of Table Mount Kit

1. Loosen both locking knobs on the clamp assembly by rotating them in a counterclockwise direction.
2. Fit the clamp assembly onto the table's side-rail.
3. Slide the assembly along the side-rail to the desired location.
4. Secure the assembly by tightening both locking knobs securely and equally.

Mounting the Powerhead to the Kit

1. Fully loosen Knob C; refer to Figure 2-12.
2. Unscrew and remove powerhead knob assembly from the bottom of the powerhead pivot assembly.

3. Lower the powerhead pivot assembly into the head bushing and secure the powerhead to the bracket by inserting the knob assembly upward through the head bushing and anchoring it in the powerhead pivot assembly.
4. Connect the end of the powerhead extension cable to the powerhead.
5. Loosen Knob B and position the powerhead as desired; secure this position by tightening Knobs B and C.
6. Verify the security of the assembly.

REMOTE STAND ASSEMBLY CATALOG NO. 601075

The Remote Stand Assembly provides a secure yet mobile support for the Angiomat 6000 powerhead.

Assembly of the Remote Stand

Separate instructions for the Remote Stand are suppled with each Remote Stand shipment.

Mounting the Powerhead to the Remote Stand

1. Unscrew and remove powerhead knob assembly from the bottom of the powerhead pivot assembly.
2. Lower the powerhead pivot assembly into the head bushing
3. Secure the powerhead to the bracket by inserting the knob assembly upward through the head bushing and anchoring it in the powerhead pivot assembly.
4. Connect the end of the powerhead cable to the powerhead extension cable.

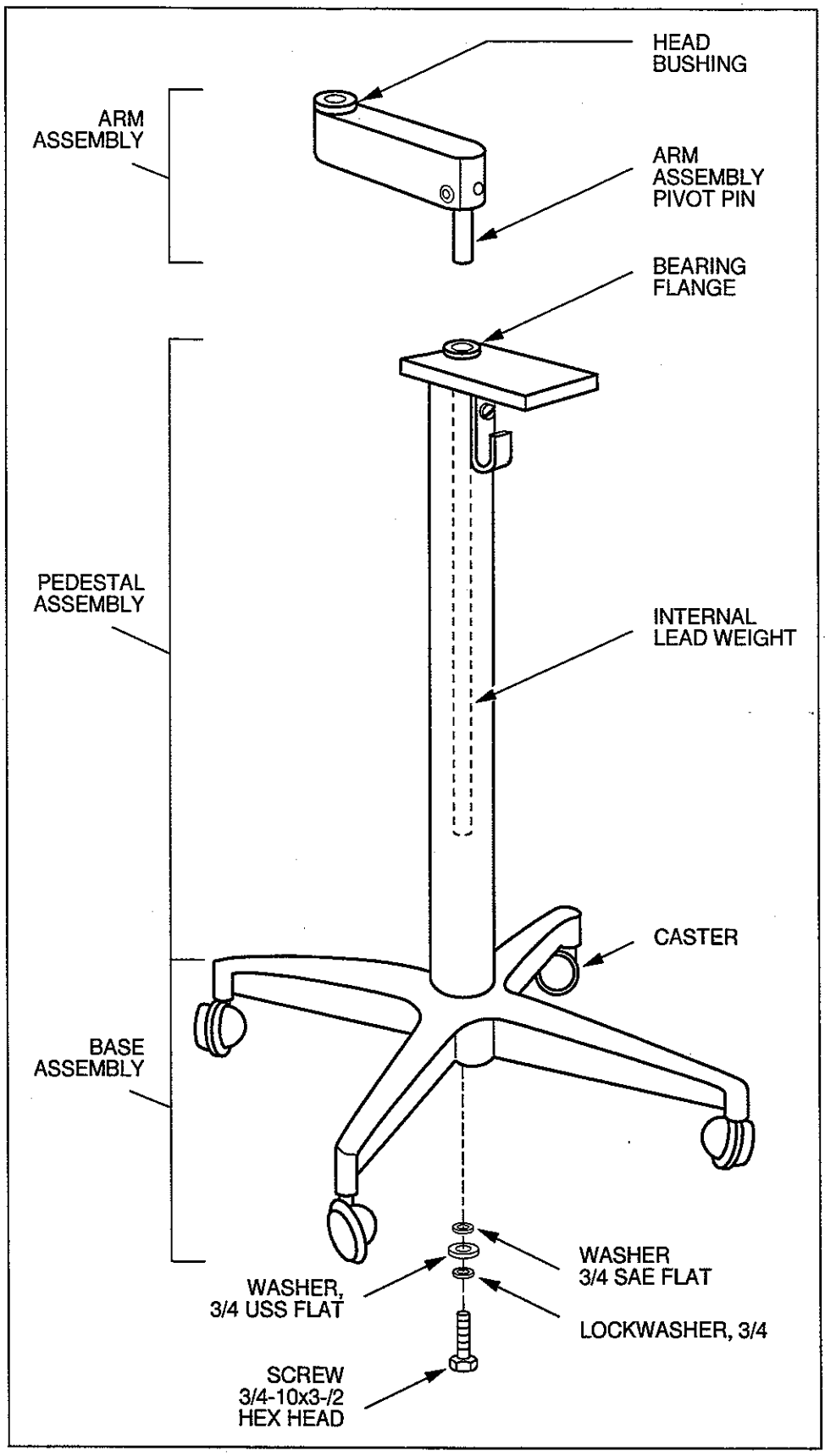


Figure 2-13
Remote Stand Assembly

POWER

Either 115 VAC or 230 VAC power connects to the Base or Electronics Cabinet. The power requirement of your specific unit will be marked on the rear of the unit's Base or Electronics Cabinet.

LANGUAGE

Chip U12 on the Main Processor board contains all text information that is forwarded to the Console for display. This text can be display in English, German or French. The default configuration for the unit is English. By changing the jumper configurations, German and French can be displayed.

Refer to Chapter 6 for information on how to access the Main Processor board. Configure the jumpers in accordance with Table 2-5 in order to meet your specific needs.

Language	*JP1*	*JP2*
English		
German	connected	
French		connected

Table 2-5
Jumper Configuration of Main Processor Board

REMOTE START CONTROLS

REMOTE START HANDSWITCH

Part Number	*Name and Description*
601131	Retractable Handswitch — 115 VAC only
601082	Retractable Handswitch — 230 VAC only
600121	25 ft. Handswitch — 115 VAC only
601076	25 ft. Handswitch — 230 VAC only
600127	40 ft. Handswitch — 115 VAC only
601077	40 ft. Handswitch — 230 VAC only
601257	80 ft. Handswitch — 115 VAC only

Table 2-6
Remote Start Handswitch P/N

REMOTE START FOOTSWITCH

Part Number	Name and Description
600120	25 ft. Footswitch

Table 2-7
Remote Start Footswitch P/N

ECG TRIGGER OPTION WIRING

The Angiomat 6000 ECG Option consists of the following components:

- ECG Trigger/Amplifier
- Pre-amplifier (extra-cost option)

ECG Trigger/Amplifier

If a high-level ECG signal (1 volt) is available from a physiological monitor it can be applied to pins 2 and 4 of the ECG input connector on the Angiomat Support column. Such a signal will be sufficient for internal processing and triggering.

Pre-amplifier

The pre-amplifier (P/N 600137) is used to amplify the ECG taken from the electrodes on the patient to a standard 1 volt level for input into the Angiomat 6000 Injector.

The pre-amplifier consists of the amplifier contained within an enclosure, two cables exiting from the enclosure, and a Bracket which allows the pre-amplifier to be hung on a rail on the side of a catheterization table. The pre-amplifier meets all requirements of the following for patient connections:

- U.L. 544
- AAMI
- IEC 601-1

The pre-amplifier may be tested for any of these requirements, however, it is **not recommended** to perform repeated tests of the 2500 volt U.L. 544 Dielectric Strength Test. Repeated testing will damage the isolation amplifier.

Interconnecting cables for the Angiomat 6000 and ECG equipment attach to connectors mounted on the rear of the Support column. Descriptions of the connectors and cables follow:

ECG Input

The ECG input, connector J3, is a 5-pin DIN receptacle, flange-type connector located on the rear of the Injector Base or rack mount unit. This connector accepts signals from ECG monitors and pre-amplifiers. Pin 2 of J3 is the High Level ECG input signal. Pin 4 is signal ground. Use the LF Interface Cable (P/N 600136).

ECG Output

The ECG output, connector J4, is a 4-pin DIN receptacle, flange-type connector located on the rear of the Injector Base or rack mount unit. This connector provides feedback signals to an ECG monitor as the Angiomat 60000 performs ECG-triggered injections. Pin 4 is signal ground. Use the LF Interface Cable (P/N 600135).

Normal Output—Pin 1 of J4 is the High Level ECG output signal with start and stop signals. Usually the Angiomat is connected to an external oscilloscope to display the patient's ECG. This is desirable to set the delay and duration of each "injection" within a cardiac cycle. A marker is inserted electronically in the patient's trace to indicate the beginning of the injection. A second marker is inserted in the trace when in multiple ECG to indicate the stop point of the injection.

Auxiliary Output—Pin 2 is the R-wave synchronization (TTL signal). This signal is a 5-volt, 100 millisecond pulse and is placed on each R-wave. It may be used to gate an X-ray.

IMAGING SYSTEM

The Angiomat 6000 can be interfaced with any film changer, programmer, or digital imaging system. There are a number of ways to interconnect the column and the imaging system.

The first portion of this section covers the general technical details of triggering the injector to start, and to trigger the imaging system from the injector.

The following portion summarizes the cables available for specific models of film changers.

The last portion gives the wiring details on certain models of film changers, including cables to use, and how to wire the system for specific operation.

GENERAL INTERFACING DETAILS

The Universal Interface in the Angiomat 6000 allows you to link the injector to the imaging system or synchronization, control, and to exchange information.

This interface allows the injector and imaging system to trigger each other, and it provides status and control lines between the injector and imaging system. The following is a summary of the connections possible with the Universal Interface. A general wiring diagram is shown in Figure 2-14.

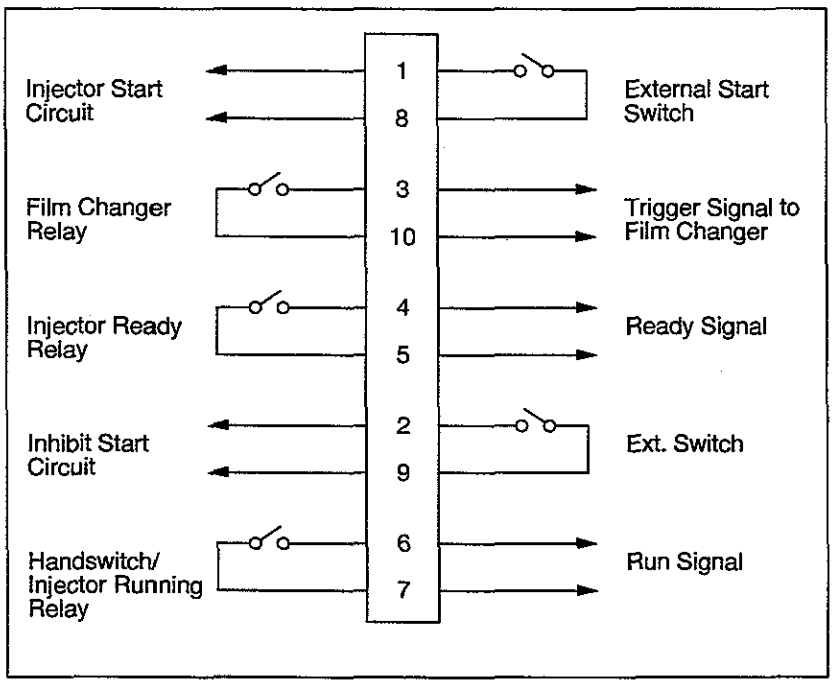


Figure 2-14
Universal Interface

Film Changer/X-Ray Start (from the Injector)

To trigger the film changer from the Angiomat 6000, connect to pins 3 and 10 of the universal interface connector. These connections are controlled by the X-Ray Delay timer in the Angiomat 6000. These contacts will close to trigger the imaging system. They will open when the start switch is opened.

These relay contacts are isolated from the injector. No voltage or other circuitry is connected to them. These contacts may control up to 220 VAC at up to 1 amp.

Injector Start (to the Injector)

To trigger the Angiomat 6000 to start from the imaging system, connect to pins 1 and 8 of the universal interface connector. Use a pair of normally open contacts, such as on a relay or push-button switch, to start the injector. When the contacts close, the injector start circuit will be enabled.

The injector will stop when these contacts open, provided the injector's start switch is not held closed.

CAUTION!
The external start connection MUST NOT apply voltage to the start circuit. Only a switch closure may be provided.

DANGER!
When the injector is wired to be started externally, the operator does not have full control of the injector with the standard hand switch. The hand switch may be used to start the injector as normal, but once the external start contacts are closed, the injector's hand switch CANNOT be used to stop the injector. To stop the injection, all start switches must be open or the DISABLE switch depressed on the Console. Failure to stop an injection can result in serious patient injury

Injector Ready (from the Injector)

These contacts, pins 4 and 5 of the universal interface connector, are closed when the injector is enabled, open when it is disabled. This signal can be used as a "ready to inject" status line. It is useful for hookup verification by the operator at the imaging system's Console.

Inhibit Injector (to the Injector)

By providing a pair of contacts to pins 2 and 9 of the universal interface connector, the remote start can be inhibited. However, the Console start will function normally.

Injector Running (from the Injector)

These contacts, pins 6 and 7 of the universal interface connector, are closed when the injector is running, open when it is in standby. This status line from the injector indicates when an injection is occurring. It is useful for timing, synchronization and as a status indicator.

IMAGING SYSTEM CABLES

These cables allow connecting the injector to the imaging system. Details are given under specific models of film changers and programmers.

Part Number	*Name and Description*
302806	Universal Interface Cable 20 ft. cable with open wires (no connector) at film changer end for CGR, Franklin, etc.
600134	Universal Interface Cable to AOTS, AOT890 and PUCK Mates with Elema-Schonander film changers using 8-pin Tuchel connector
600180	Universal Interface Extension Cable, 20 ft. Extension for any of the universal interface cables
600181	Universal Interface Extension Cable, 40 ft. Extension for any of the universal interface cables
600182	Universal Interface Cable to AOT DST/840 Mates with Elema-Schonander AOT DST/840 film changers using 4-pin Jones connector
600183	Universal Interface Adapter Cable Allows any universal interface cable to plug into the Angiomat 6000 with 4-pin film changer connector instead of 10-pin universal interface connector.
600184	Angiomat 3000-to6000 Adapter Cable Allows the Angiomat 6000 to plug into a room wired for the Angiomat 3000 without further modification.

Table 2-8
Imaging System Cables

INTERFACING THE ANGIOMAT 6000 TO FILM CHANGERS

This section covers the specific details for connecting the Angiomat 6000 to certain film changers including the cables required, and the wiring at the film changer.

For other film changers, refer to General Interfacing Details, this Chapter. These models of film changers and programmers are covered on the following pages:

- Elema-Schonander AOT-R/P Series, DST-840 and DST-890
- Elema-Schonander AOT-S Series
- Elema-Schonander PDQ-2 Program Control
- Elema-Schonander Puck Models
- Elema-Schonander SEP Model
- Franklin F200
- Franklin Solid State

ELEMA-SCHONANDER AOT-R/P SERIES, DST-840

Angiomat starts the Programmer; Use Cable 600182.

Remove the 4-pin dummy plug from position E on the PGQ programmer. Insert the 4-pin male square plug from the Cable into position E on the programmer. Plug the connector at the other end into the injector.

With this connection, the programmer will start when the trigger signal is given from the injector. The injector's start switch must be held closed for the duration of the programmer's cycle. Releasing the start switch will terminate the injector and programmer.

ELEMA-SCHONANDER AOT-R/P SERIES, DST-890

Angiomat starts the Programmer; Use Cable 600134.

Remove the 8-pin dummy Tuchel plug from position 1515 on the PGQ-P programmer. Insert the 8-pin plug from the Cable into position 1515 on the programmer. Plug the connector at the other end into the injector.

With this connection, the programmer will start when the trigger signal is given from the injector. The injector's start switch must be held closed for the duration of the programmer's cycle. Releasing the start switch will terminate the injector and programmer.

ELEMA-SCHONANDER AOT-S SERIES

2-way connection: Film Changer starts the Angiomat; Angiomat starts the Film Changer. Use Cable 600134. Also required—Injector socket (Elema-Schonander part number 60-44-440-B1945)

Run six lines from AMP connector k65 in the Program Selector through the table Base to the added female connector (see Figure 2-19). Connect a jumper between pins 3 and 7 of k65. On PDA pc board D368 (D345 on Angiomatic), be sure there is a jumper in the S position.

Open the 8-pin connector plug and add a jumper between pins 1 and 2. With this connection, when the film changer handswitch is activated to its "expose" position, only the injector is started. Following the selected film changer delay time, a contact in the injector closes the circuit to the film changer. If an injector delay tie is selected, the film changer starts immediately and the injector follows after the delay. With this connection, the "inject" line on the punch card is not used.

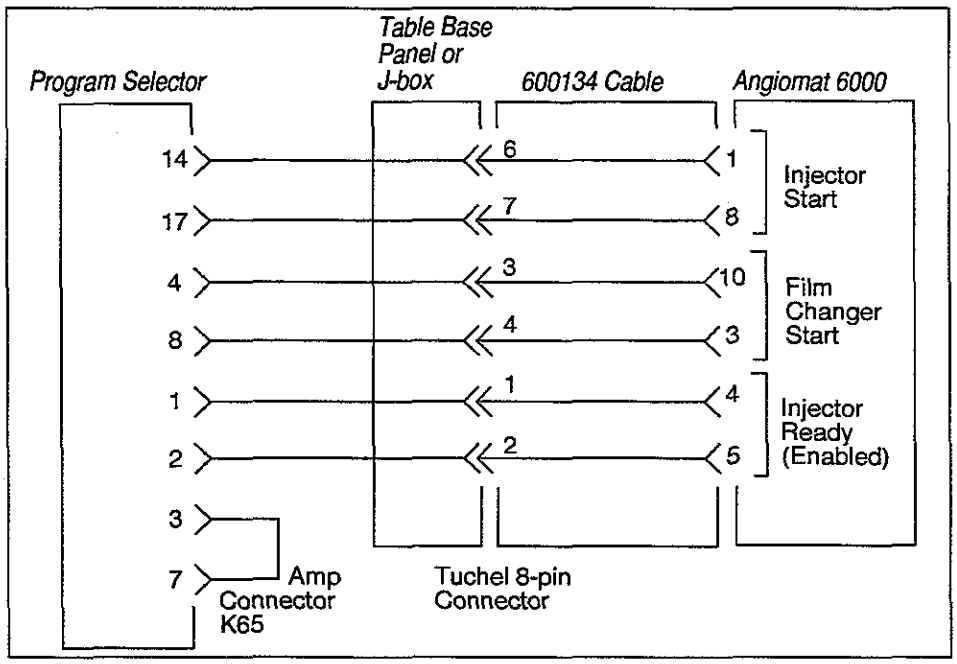


Figure 2-19
Elema-Schonander AOT-S Wiring for Bidirectional Triggering

DANGER!
The film changer handswitch connected to the PDA program selector is NOT a dead-man switch. To interrupt the injection once it has been started, press the stop button on the handswitch.

If this is not acceptable or does not comply with local standards, a dead-man switch may be connected in series with the lead from k65 pin 14 to the injector. The changer is then prepared as above, but the injector will start only after the additional dead-man switch is closed.

Punch card starts the Angiomat; Use Cable 600134. Also required—Injector socket (Elema-Schonander part number 60-44-440-B1945).

Run two lines from the AMP connector k65 in the Program Selector through the table Base the added female connector (See Figure 2-20). Connect a jumper between pins 3 and 7.

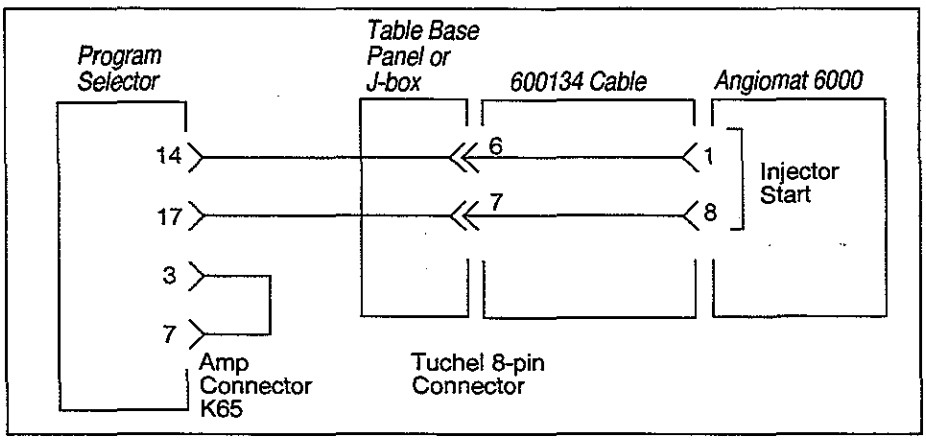


Figure 2-20
Elema-Schonander AOT-S Wiring for Punchcard Injector Starting

On PDA pc board D368 (D345 on Angiomatic), make sure that there is a jumper in the P position.

Inspect the 8-pin connector plug. If there is a jumper between pins 1 and 2, remove it. With this connection, the injector is operated from the INJECT channel in the punch card reader.

DANGER!
The film changer handswitch connected to the Puck program selector is NOT a dead-man switch. To interrupt the injection once it has been started, press the stop button on the Puck handswitch.

If this is not acceptable or does not comply with local standards, a dead-man switch may be connected in series with the lead from k65 pin 14 to the injector. The changer is then prepared as above, but the injector will start only after the additional dead-man switch is closed.

ELEMA-SCHONANDER PDQ-2 PROGRAM CONTROL

PDQ-2 starts the Angiomat; Use Cable 600134.

For proper system interlock, the film changer/injector should be controlled from the PDQ-2 handswitch. This handswitch is of a "dead man" type and when released, the injector start signal will terminate and injection will stop.

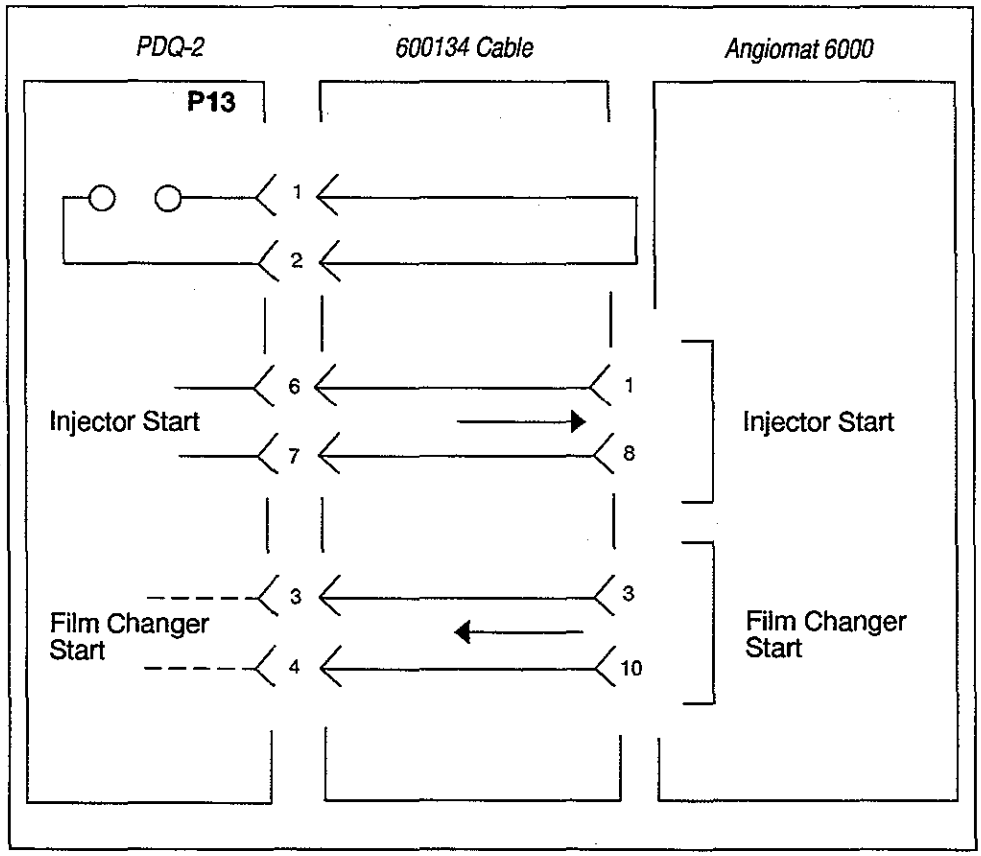


Figure 2-21
Elema-Schonander PDQ-2 Program Control Connector

Connect the Tuchel plug into connector TB-6 of the PDQ-2 Program Control. Plug the other end into the Universal Interface plug on the injector.

ELEMA-SCHONANDER PUCK MODELS

There are three basic configurations of the Puck, classified by film change rates. First determine the model, then find the configuration in the chart below. Instructions are given for each type.

Changer	*Program Selector*	*Style*	*Puck Model*
DST914	DST920	U35	2/sec
DST915	DST920	U35	2/sec
DST910	DST921	U24	3/sec
DST918	DST921	U35	3/sec
DST918	DST921	L35	3/sec
65-20-480-G025E	64-65-157-G025E	U24	3/sec-73
65-20-464-G025E	64-65-157-G025E	U35	3/sec-73
65-20-472-G025E	64-65-157-G025E	L35	3/sec-73
64-61-073-G025E	64-65-157-G025E	U35A	3/sec-73
67-48-172-G025E	64-65-157-G025E	U35(CFRP)	3/sec-73
67-48-188-G025E	64-65-157-G025E	U35A(CFRP)	3/sec-73
67-68-006-G025E	64-65-157-G025E	UD35	3/sec-73
68-28-701-G025E	68-28-214-G025E	U24	3/sec-79
68-28-503-G025E	68-28-214-G025E	U35	3/sec-79
68-28-859-G025E	68-28-214-G025E	U35A	3/sec-79
68-55-605-G025E	68-28-214-G025E	UD24	3/sec-79
68-58-506-G025E	68-28-214-G025E	UD35	3/sec-79

Puck 2/sec Models

The Angiomat starts the Film Changer; Use Cable 302806.

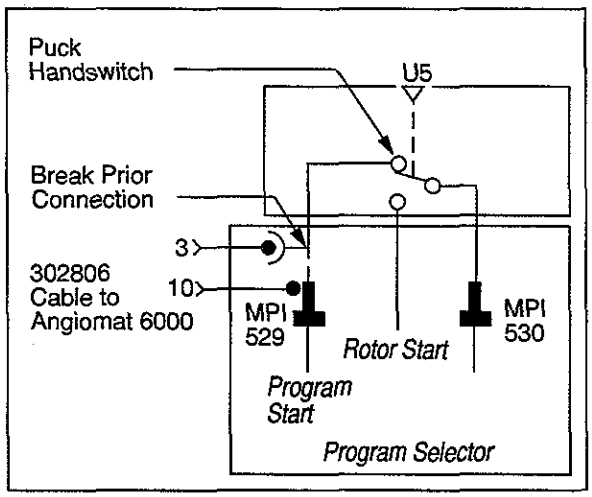


Figure 2-22
Puck 2/sec Wiring, Angiomat Starts Film Changer

Modify the program selector as shown in Figure 2-22. Lead 529 connects the Puck handswitch to the terminal board in the program selector. Break this connection. Attach the two leads for the film changer start connections (from pins 3 and 10) to the Cable leads in series with 529 connection just broken. Plug the connector at the other end of the Cable into the injector.

When the injector is not being used, install a shorting plug or switch to complete the circuit from the Puck handswitch to Mp1-529.

The Punchcard starts the Angiomat; Use Cable 302806. Also required—Relay: normally open with 240 VAC coil (Potter and Brumfield KA11AG or equivalent) and an 8-pin Tuchel plug (Elema-Schonander part number 60-44-424-B1945)

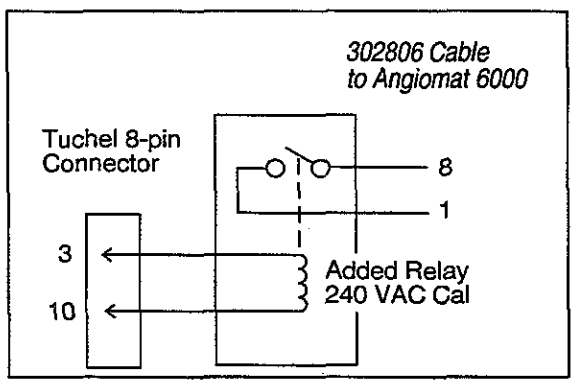


Figure 2-23
Puck 2/sec Wiring, Punchcard Starts the Angiomat

Connect the Tuchel plug into the injector outlet on the Puck junction box. Plug the other end into the injector.

With this connection, the injector is started and controlled by the Puck handswitch and punch card. The injection can be terminated at any time by pressing the stop button on the Puck handswitch.

DANGER!
The film changer handswitch connected to the Puck program selector is NOT a dead-man switch. To interrupt the injection once it has been started, press the stop button on the Puck handswitch.

If this is not acceptable, or does not comply with local standards, a dead-man switch may be connected in series with one of the leads in the Cable between the relay and the injector. The changer is then prepared as above, but the injector will start only after the additional dead-man switch is closed.

Puck 3/sec-73 Models

The Angiomat starts the Film Changer; Use Cable 600134. Also required: Puck Modification Kit (Elema-Schonander part number 760325-2)

Install the Puck Modification Kit.

Insert the Tuchel plug into the injector outlet of the Puck junction box. Plug the other end into the injector.

The Punchcard starts the Angiomat. If the Puck changer is not equipped with the Puck Modification Kit (Elema-Schonander part number 760325-2), follow the instructions for 2/sec models, under the heading of The Punchcard starts the Angiomat above. If the Puck Changer is equipped with the Puck Modification Kit, use Cable 600134. Perform the following instructions.

Insert the Tuchel plug into the injector socket of the junction box. Plug the other end into the injector. With this connection, the injector is started and controlled by the Puck handswitch and punch card. The injection can be terminated at any time by pressing the stop button on the Puck handswitch.

DANGER!
The film changer handswitch connected to the Puck program selector is NOT a dead-man switch. To interrupt the injection once it has been started, press the stop button on the Puck handswitch.

If this is not acceptable, or does not comply with local standards, a dead-man switch may be connected in series with the lead from pin 6 of the Tuchel plug to the injector. The changer is then prepared as above, but the injector will start only after the additional dead-man switch is closed.

3/sec-79 Models

Remote start of the Angiomat; the Angiomat starts the Film Changer. Use Cable 600134.

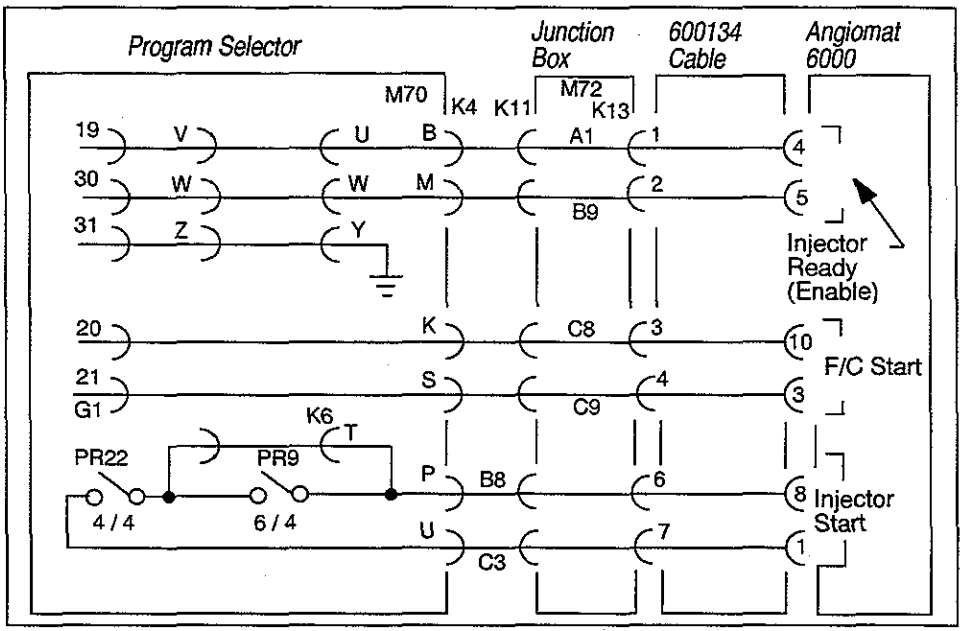


Figure 2-24
3/sec-79 Wiring, Remote Start of Angiomat, Angiomat Starts Film Changer

Modify the program selector as shown in Figure 2-24, and add these connections to the program selector:

From Puck Program Selector Connector	To
K6-S	K6-T
K6-U	K6-V
K6-W	K6-X
K6-Y	K6-Z

Open the 8-pin connector on the Cable and add a jumper between pins 1 and 2. Insert the 8-pin Tuchel plug into the injector socket of the junction box. Plug the connector at the other end into the injector.

With this connection, relay pr16 will energize and a set of contacts on this relay will remove the +UR voltage from pin 4 of the injector connector k13. This allows the film changer to be started in the serial mode by remote control.
When the Puck handswitch is depressed, relay pr22 closes, and a contact on pr22 closes between pins 6 and 7 of the Tuchel connector to start the injector. The "inject" line on the punch card is not used; This function is

bypassed by jumper lead k6-S and k6-T. Following any selected x-ray delay time, a set of contacts in the injector closes; this completes the circuit between pins 3 and 4 of the Tuchel plug to start the changer.

DANGER!
The film changer handswitch connected to the Puck program selector is NOT a dead-man switch. To interrupt the injection once it has been started, press the stop button on the Puck handswitch.

If this is not acceptable, or does not comply with local standards, a dead-man switch may be connected in series with the lead from pin 6 of the Tuchel plug to the injector (also connected to b8 of M72 in the junction box, and to pin P of M70 in the program selector). The changer is then prepared as above, but the injector will start only after the additional dead-man switch is closed.

Manual start of the Angiomat; the Angiomat starts the film changer; Use Cable 600134.

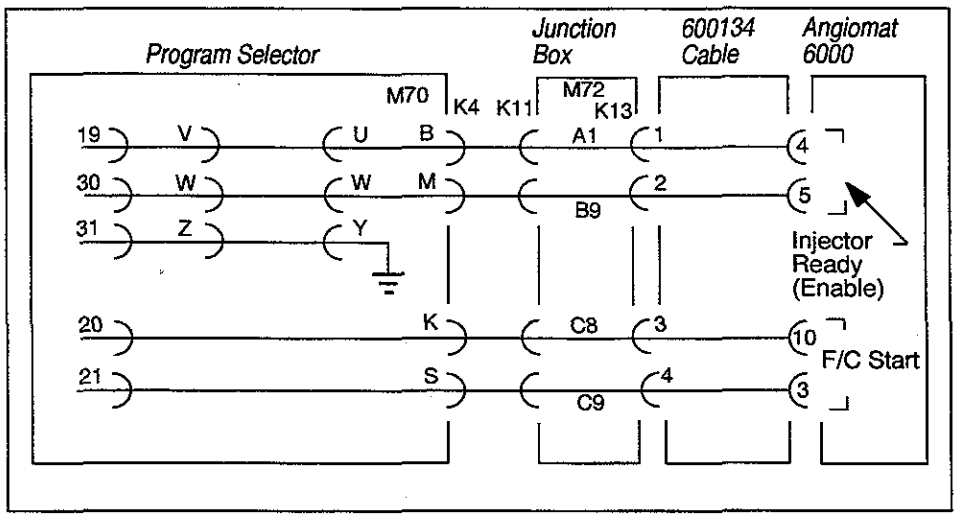


Figure 2-25
3/sec-79 Wiring, Manual Start of Angiomat, Angiomat Starts Film Changer

Modify the program as shown in Figure 2-25, and add these connections to the program selector:

From Puck Program Selector Connector	To
K6-U	K6-V
K6-W	K6-X
K6-Y	K6-Z

Open the 8-pin connector on the Cable and add a jumper between pins 1 and 2. Insert the 8-pin Tuchel plug into the injector socket of the junction box. Plug the connector at the other end into the injector.

With this connection, relay pr16 will energize and a set of contacts on this relay will remove the +UR voltage from pin 4 of injector connector k13. This allows the film changer to be started in the serial mode by remote control.

The changer and x-ray generator are activated by the Puck handswitch, then the injector is started through its own handswitch. A contact in the injector, connected between pins 3 and 4 of injector plug k13, will then start the film changer.

The Punchcard starts the Angiomat; Use Cable 600134.

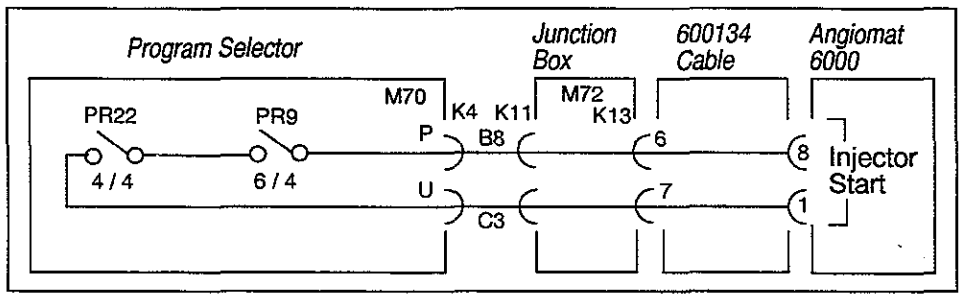


Figure 2-26
3/sec-79 Wiring, Punchcard Starts the Angiomat

Inspect the 8-pin connector on the Cable. If there is a jumper between pins 1 and 2, remove it.

Insert the 8-pin Tuchel plug into the injector socket of the junction box. Plug the connector at the other end into the injector.

Refer to Figure 2-26. When a punch card is programmed for an injection and placed in the card reader, relay pr9 will energize. Contacts in relays pr9 and pr22 will close the circuit connected to pins 6 and 7 of the Tuchel connector to start the injector. Relay pr22 is controlled from the Puck handswitch during serial operation. Relays pr9 and pr22 will remain closed for the duration programmed on the punch card.
The injection can be terminated by pressing the stop button on the Puck handswitch.

The film changer handswitch connected to the Puck program selector is NOT a dead-man switch. To interrupt the injection once it has been started, press the stop button on the Puck handswitch.

If this is not acceptable, or does not comply with local standards, a dead-man switch may be connected in series with the lead from pin 6 of the Tuchel plug to the injector (also connected to b8 of M72 in the junction

box, and to pin P of M70 in the program selector). The changer is then prepared as above, but the injector will start only after the additional dead-man switch is closed.

ELEMA-SCHONANDER SEP MODEL

2-way connection: Film Changer starts the Angiomat; Angiomat starts the Film Changer. Use Cable 600134.

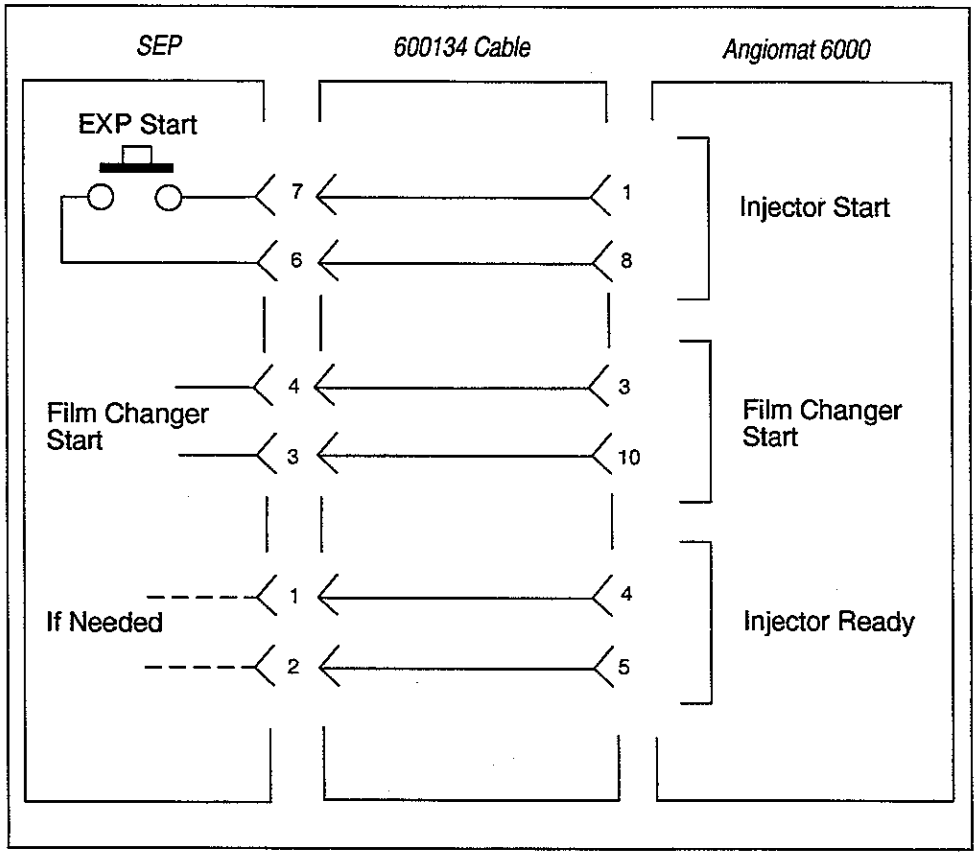


Figure 2-27
SEP Wiring, 2-way Triggering

The SEP should be wired for 2-way handshaking operation, with the SEP starting the Angiomat, and the Angiomat sending a trigger signal back to the SEP. This wiring is shown in Figure 2-27. For further details refer to General Interfacing Details, this Chapter.

With this connection, when the film changer handswitch is activated to its "expose" position, only the injector is started. Following the selected film changer delay time, a contact in the injector closes the circuit to the film changer. If an injector delay time is selected, the film changer starts immediately and the injection follows after the delay.

Newer SEP models use a dead-man switch. See Figure 2-28 for SEP instructions and junction box wiring.

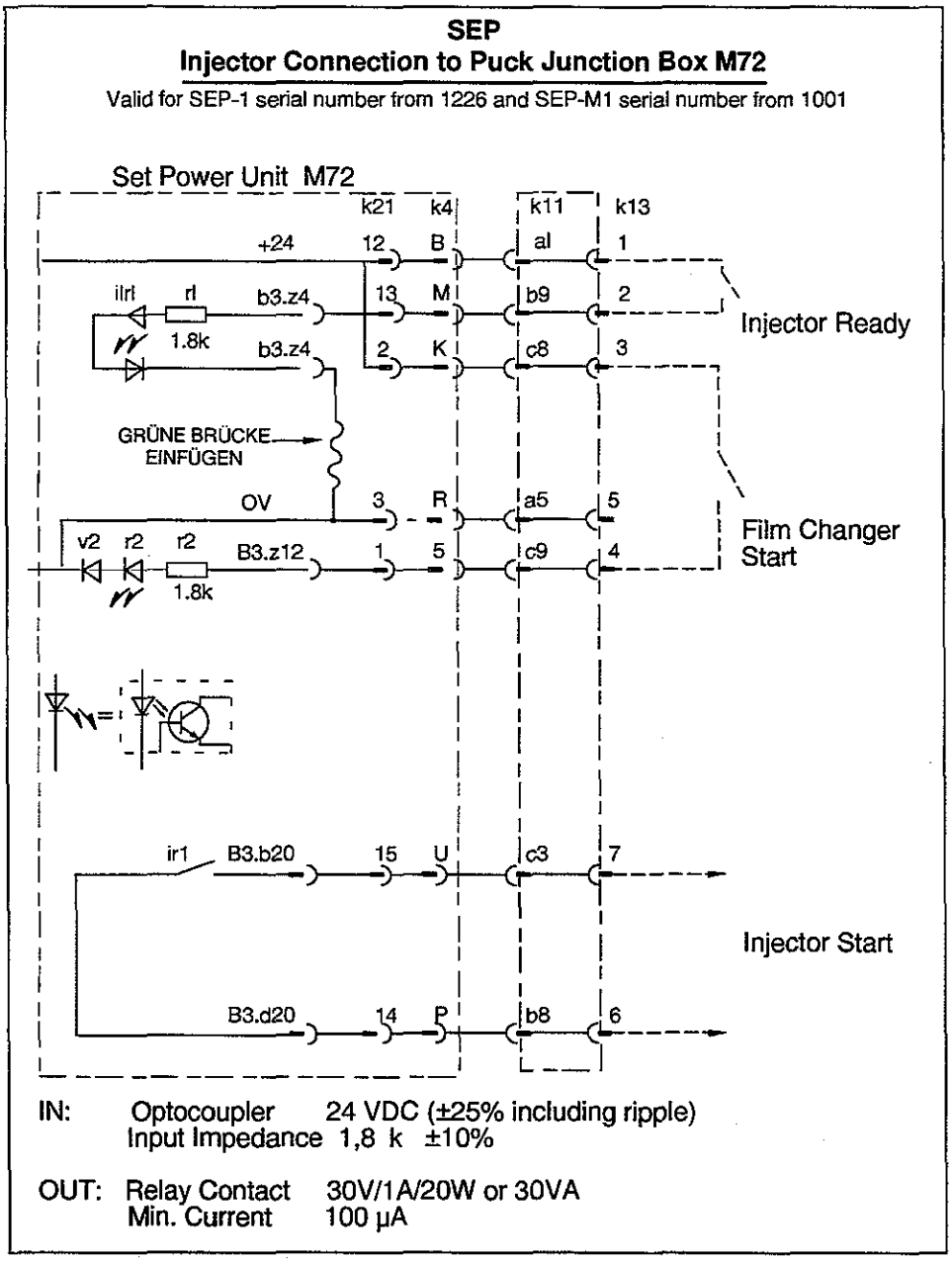


Figure 2-28
SEP Instructions and Junction Box Wiring

Angiomat starts the film changer. Use Cable 600134.

The following signals are transmitted between the SEP 90 and the injector.

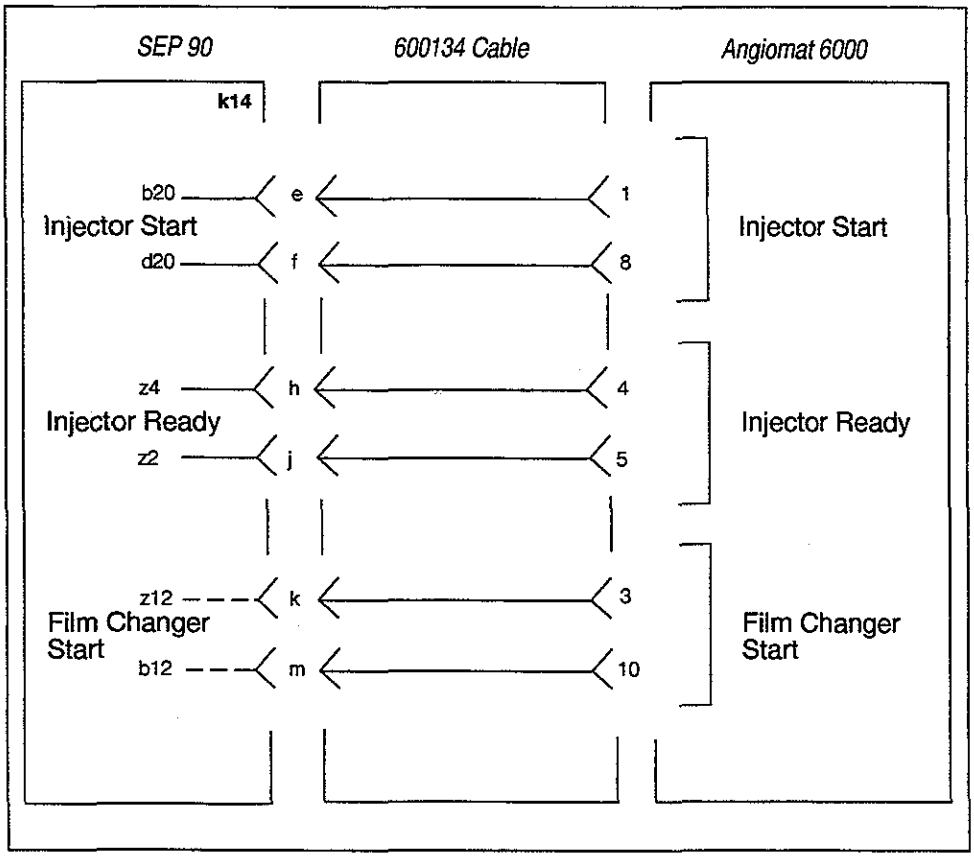


Figure 2-29
SEP 90/Injector Connections

Connect the Tuchel plug into the connector k14 of the SEP 90 Program Selector. Plug the other end into the injector.

3 CHECKOUT

This procedure checks the performance of the major functions of the Angiomat 6000. ***All Angiomat 6000 Digital Injection Systems must include a thorough checkout before use.***

This checkout is recommended at these times:

- Before using the unit for the first time;
- As part of a routine preventive maintenance program
- If a problem or mis-calibration is suspected;
- After repairs.

Be certain to read through the steps carefully before performing them. Some steps in this procedure require more than one observation or require a sequence to be timed.

If this procedure cannot be completed or if the Angiomat 6000 doesn't perform as described, stop the checkout and discontinue use of the injector. Call for service.

ITEMS REQUIRED

- A stopwatch, or a watch with a digital seconds timer
- An ohmmeter
- A syringe (for the pressure checks)
- L-F Pressure Test Fixture (Part Number 600867), consisting of Luer-Lock adapter, gage and valve
- Angiomat 6000 Installation Checklist

POWER-UP CHECK

1. Prepare the Injector.
   - Disconnect any cables connected to external equipment (such as film changers or options).
   - Remove any syringes from the pressure jacket on the head.
   - Close and lock the pressure jacket plate.
2. Check the injector's initial response:
   - Plug in the Angiomat 6000, then press the power switch to turn it on.

CAUTION!
Be sure the AC line matches the voltage and frequency on the label on the rear of the base. Any other voltage or frequency will damage the Angiomat 6000.

All display pixels and console LED's should light and stay lit for 5 seconds. Afterwards, the System Display should state this message:

—PERFORMING POWER UP SYSTEM TESTS—

(The bottom line of display will contain information about the particular version of software in the machine.)

After about 25 seconds, the System Display should show the preferred injection program, or state this message:

I CANNOT FIND ANY SAVED INJECTIONS USE
SELECT KEYS TO ENTER VALUES

3. Check these items:
   - The power switch should light.
   - These LEDs should light; all others should be out:
     - X-Ray Delay or Inject Delay
     - Transition Time or Injection Duration
     - Programmed Flow
     - Programmed Volume
     - Pressure Limit

POWERHEAD OPERATION CHECK

1. Check the Indicators:
   - Both the Enabled and Injecting indicator should be out.
   - One of the Syringe Size indicators (125, 150 or 260) should be lit, but not both.
   - The syringe heater should feel warm.

2. Check for smooth motion:
   - Press the forward key (arrow pointing to front). The plunger should not move. Hold down the Forward Key and tap the Fast Key once. The plunger should move with a smooth sound coming from the motor and gear train. Continue holding the Forward key down until the plunger slows down as it reaches the end of travel. The Volume Remaining indicator should be within 1 ml of the 0 ml position.
   - Press the reverse key (arrow pointing to rear). The plunger should not move. Hold down the Reverse Key and tap the Fast Key once. The plunger should move with a smooth sound. There should be no sounds of rubbing, scraping or grinding. Continue holding the Reverse key down until the plunger slows down as it reaches the end of travel. The Volume Remaining indicator should be within 1 ml of the 125, 150 or 260 ml position.
   - Now press and hold the Forward key and the Fast key. The plunger will gradually increase speed as both keys are pressed. Release the Fast key to stop increasing speed.
   - Now press and hold the Reverse key and Fast key. The plunger will gradually increase speed as both keys are pressed. Release the Fast key to stop increasing speed.

3. Check the loading speed:

For 125 ML syringes:
   - Using the Reverse and Fast keys, position the plunger to the 125 ml mark. Then, press and hold the Forward key and tap the Fast key once. The plunger should reach the 0 ml mark (± 1 ml) within 40-50 seconds.
   - Now press and hold the Reverse key and tap the Fast key once. Beginning at the 0 ml mark, the plunger should reach the 125 ml mark (± 1 ml) within 40-50 seconds.
   - Press and hold the Forward key and the Fast key simultaneously. Release the Fast key when the plunger is running at maximum speed. The plunger should reach the 0 ml mark (± 1 ml) within 10-16 seconds.
   - Press and hold the Reverse key and the Fast key simultaneously. Release the Fast key when the plunger is running at maximum speed. The plunger should reach the 125 ml mark (± 1 ml) within 10-16 seconds.

For 150 ML syringes:
   - Using the Reverse and Fast keys, position the plunger to the 150 ml mark. Then, press and hold the Forward key and tap the Fast key once. The plunger should reach the 0 ml mark (± 1 ml) within 44-54 seconds.
   - Now press and hold the Reverse key and tap the Fast key once. Beginning at the 0 ml mark, the plunger should reach the 150 ml mark (± 1 ml) within 44-54 seconds.

- Press and hold the Forward key and the Fast key simultaneously. Release the Fast key when the plunger is running at maximum speed. The plunger should reach the 0 ml mark (± 1 ml) within 6-12 seconds.
- Press and hold the Reverse key and the Fast key simultaneously. Release the Fast key when the plunger is running at maximum speed. The plunger should reach the 150 ml mark (± 1 ml) within 6-12 seconds.

For 260 ML syringes:

- Using the Reverse and Fast keys, position the plunger to the 260 ml mark. Then, press and hold the Forward key and tap the Fast key once. The plunger should reach the 0 ml mark (± 1 ml) within 120 seconds.
- Now press and hold the Reverse key and tap the Fast key once. Beginning at the 0 ml mark, the plunger should reach the 260 ml mark (± 1 ml) within 120 seconds.
- Press and hold the Forward key and the Fast key simultaneously. Release the Fast key when the plunger is running at maximum speed. The plunger should reach the 0 ml mark (± 1 ml) within 15 seconds.
- Press and hold the Reverse key and the Fast key simultaneously. Release the Fast key when the plunger is running at maximum speed. The plunger should reach the 260 ml mark (± 1 ml) within 15 seconds.

If the Angiomat 6000 Injector does not meet the criteria detailed in the above checks, remove the injector from use and contact your qualified service representative.

FUNCTIONAL CHECKS

1. Press the Select key under X-ray delay. The System Display just above Inject Delay should show ___S.
2. Press the Select key under Injection Duration so the LED next to Transition Time lights and the System Display shows ___S.
3. Press the Select key under Achieved Flow. The LED next to Programmed Flow should be lit, and the System Display should show ___ml/S. Press the Data Entry keys to set a Programmed Flow of 5 ml/sec.
4. Press the Select key under Achieved Volume. The LED next to Programmed Volume should be lit, and the System Display should show ___ml. Press the Data Entry keys to set a Programmed Volume of 25 ml.

5. Press the Select key under Achieved Pressure. The LED next to Pressure Limit should be lit, and the System Display should show ___PSI (or another pressure unit). If any pressure unit except PSI is displayed, press the Units key until PSI is shown in the display or another pressure unit. Press the Data Entry keys to set a Pressure Limit of 1000 PSI.

6. Press the Enable key. System Display should show this message:

[YES] TO CONFIRM VALUES	OR	FILL SEQUENCE NOT PERFORMED - CHECK
[NO] TO CHANGE		SYRINGE - TO OVERRIDE PRESS 9.

7. Press the 9 key. System Display should show this message:

YES FOR XXX ML SYR. - NO AIR INJ. VOL. = XX
DISABLE FOR VOLUME CHANGE SYR. VOL. = XXX

NOTE: *As an additional precaution against the injection of air, all versions of the system software will check for the required fill sequence. This requirement is fulfilled whenever the operator performs the following:*
1) Runs the plunger to (0). The powerhead can be in any position while this is done.
2) Moves the powerhead to the vertical position (syringe pointing upward)
3) Retracts the plunger back into the powerhead to fill syringe. Therefore this procedure will normally have been performed during the filling of a syringe. However, if any of the following conditions exist:

- *Pre-filled syringes are used.*
- *Locking knob on syringe face plate has been opened.*
- *Injector is turned off, then on again.*

The injector will interpret the condition as a new syringe and display the "REQUIRED FILL SEQUENCE" message. In this case, the message may be overridden by pressing the "9" key.

8. Press the Yes key. These things should happen:
   - On the head, Enabled should light. (Indicated by yellow light)
   - On the control panel, the LED next to Enable should light.
   - System Display should show this message:

READY TO INJECT

9. Press and hold the start switch to inject (keep the start switch pressed until the end of this step). *An injection can also be started by pressing and holding the START key while pressing the YES key on the console. For injections run at 5 ML/S or less, both keys can be released once the injection begins. For injections run at greater than 5 ML/S, the yes key must be pressed until the injection has been completed.*

During the injection, the injecting indicator on top of the powerhead

should light. This light remains on until the injection is performed. Then, the ENABLED light comes back on until the start switch is released.

10. At the end of the injection, look for these responses:

- The System Display will show the total volume delivered since the last time the New Patient key was pressed.
- The System Display will also show the actual values for the injection just completed.
- The LEDs will light next to Injection Duration, Achieved Flow, Achieved Volume and Achieved Pressure.
- The top line of the System Display should state:

DONE. VOL. REM=XX TOTAL VOL=XX

The achieved values shown on the System Display should be within these ranges:

Injection Duration	4.5 - 5.5 seconds
Achieved Flow Rate	4.5 - 5.5 ml/S message:
Achieved Volume	24 - 26 ml
Achieved Pressure	less than 50 PSI

11. Press the Reverse key and Fast key to fully retract the plunger.

12. Repeat the injection tests with the Programmed Flow and Volume shown in the chart below. After each injection, compare the results shown in the System Display with the expected values shown in the chart.

Programmed		*Achieved*		*Injection*
Flow	Volume	Flow	Volume	Duration
2 ml/s	2 ml	1.5-2.5 ml/s	1.5-2.5 ml	0.8-1.2 sec
5 ml/s	5 ml	4.5-5.5 ml/s	4.5-5.5 ml	0.8-1.2 sec
10 ml/s	10 ml	9.5-10.5 ml/s	9.5-10.5 ml	0.8-1.2 sec
20 ml/s	20 ml	19-21 ml/s	19-21 ml	0.8-1.2 sec
20 ml/s	50 ml	19-21 ml/s	49-51 ml	2.2-2.6 sec
20 ml/s	100 ml	19-21 ml/s	98-102 ml	4.5-5.5 sec

NOTE: *Achieved pressure should be less than 100 PSI in all these checks.*

13. Program the injector to deliver 50 ml at 20 ml/s. Enable and start the injection. Press the disable key. Make sure that the injector stops deliver of the injection.

14. Press the remote switch to ensure that the switch is not sticking opened or closed at any time.

ML/M CHECK

1. Press the Reverse key and Fast key to fully retract the plunger.
2. Press the Select key under Achieved Flow. The LED next to Programmed Flow should light. Press the Units key so ml/M appears in the System Display. Set the Programmed Flow at 40 ml/M.
3. Set the Programmed Volume at 20 ml.
4. Press Enable, press 9 to override fill sequence if necessary, then press Yes in response to messages from the System Display.
5. Press the Yes key and the Start key (on the control panel) at the same time, then release. The injector will latch and continue running.
6. At the end of the injection, the System Display should show these values:

Injection Duration	28-32 seconds
Achieved Flow Rate	38-42 ml/M
Achieved Volume	19-21 ml
Achieved Pressure	less than 100 PSI

ML/H CHECK

1. Press the Reverse key and Fast key to fully retract the plunger.
2. Press the Select key under Achieved Flow. The LED next to Programmed Flow should light. Press the Units key so ml/H appears in the System Display. Set the Programmed Flow at 40 ml/H.
3. Set the Programmed Volume at 4 ml.
4. Press Enable, press 9 to override fill sequence if necessary, then press Yes in response to messages from the System Display.
5. Press the Yes key and the Start key at the same time or press the Start Switch.
6. At the end of the injection, the System Display should show these values:

Injection Duration	330-390 seconds (nominal 6 mins)
Achieved Flow Rate	38-42 ml/H
Achieved Volume	3.5-4.5 ml
Achieved Pressure	less than 100 PSI

TIMER CHECK (INJECTION DELAY)

1. Press the Reverse key and Fast key to fully retract the plunger.
2. Press the Select key under Achieved Flow. The LED next to Programmed Flow should light. Press the Units key so ml/S appears in the System Display. Set the Programmed Flow at 6 ml/S.
3. Set the Programmed Volume at 90 ml.
4. Press the Select key under Inject Delay so the LED next to Inject Delay lights. Set a delay of 15 seconds.

4. While delivering injection, slowly close valve until a pressure of 750 psi is indicated on the gauge.
5. Run the second half of the syringe at the 750 psi indication. At the end of the injection, the achieved pressure readout in the system display should read approximately 750 psi *and* the Pressure Limit LED on the control console should not be lit.
6. If the injector performs as indicated in Step 5, repeat Steps 3 and 4 at a pressure gauge reading of 1000 psi. At the end of this injection, the achieved pressure readout in the system display should read 1000 psi and the Pressure Limit LED should be lit.

PRE-PROGRAMMED INJECTION CHECKS

NOTE: The following procedure assumes that injection #1 resides in memory and automatically appears after power to the unit is turned on and the power-up test is completed. If your unit does not have injection test #1 with the values listed in step 1 saved in memory, the display will read " I cannot find any saved injections. Use the select keys to enter values". If the control circuitry detects a problem, a fault message will appear (fault messages are discussed in chapter 5). If the "Select keys" message appears, use the select keys to enter the values listed in step 1. Follow the remaining steps as they are written below.

1. Turn unit off. Wait several seconds, then turn on power to the Angiomat. After the Power Up and Self Test, Test #1 should appear in the display with the following values for the following parameters:

Programmed Flow	10 ml/S
Programmed Volume	20 ml
Pressure Limit	600 PSI

2. Press the Reverse key and the Fast key to fully retract the plunger.
3. Press Enable, press 9 to override fill sequence if necessary, then press Yes in response to messages from the system display.
4. Press and hold the remote start switch. At the end of the injection, release the remote start switch. The system display should show these values:

Injection Duration	1.5 - 2.5 seconds
Achieved Flow Rate	9.5 -10.5 ml/S
Achieved Volume	19-21 ml
Achieved Pressure	less than 50 PSI

4 DESCRIPTION OF OPERATION

This Chapter describes the design and function of the Angiomat 6000 System. A block diagram is included at the end of each section in order to supplement the description. Board schematics are contained in Chapter 9.

The overall system is covered first, describing the main design features. The remainder of this Chapter details the circuit groups. For each circuit group, a description of its major functions and summary of its inputs and outputs is included.

OVERALL SYSTEM DESIGN

The Angiomat 6000 contains two velocity control loops. The first loop gives approximate speed control, while the second loop corrects or trims the velocity for zero steady-state error. Refer to Figure 4-1 and Figure 4-2.

Main Velocity Loop

In the first velocity loop, an 8-bit word from the processor sets the desired flow rate. Through a D-to-A converter, an analog command is supplied to a difference amplifier in the servo. This is compared to the motor's back-EMF, which is proportional to actual flow rate. The difference between the desired rate and the actual rate drives the motor.

Velocity Correction Loop

In the velocity correction loop, pulses from the processor (desired flow rate) are compared to pulses from the incremental encoder in the powerhead (actual flow rate). By integrating the difference between the pulse rates, the circuits derive a velocity correction factor. This correction factor feeds into the difference amplifier on the servo, to be summed with the analog signals for desired and actual flow rate. When the actual and desired flow rates are equal, the velocity correction factor is zero.

Volume Control

Volume is controlled by one circuit, and the plunger's position (equal to volume injected) is monitored by a second circuit. First, for accurate volume delivery, the processor counts the pulses from the incremental encoder. Second, the Angiomat 6000 monitors the position of a potentiometer and compares it to a desired position command. The desired position command is derived by an 8-bit word from the processor through a D-to-A converter. If the actual position exceeds the desired position, a volume fault occurs to stop the injection. In essence, this second circuit is an "electronic stop" to guard against an over-volume injection.

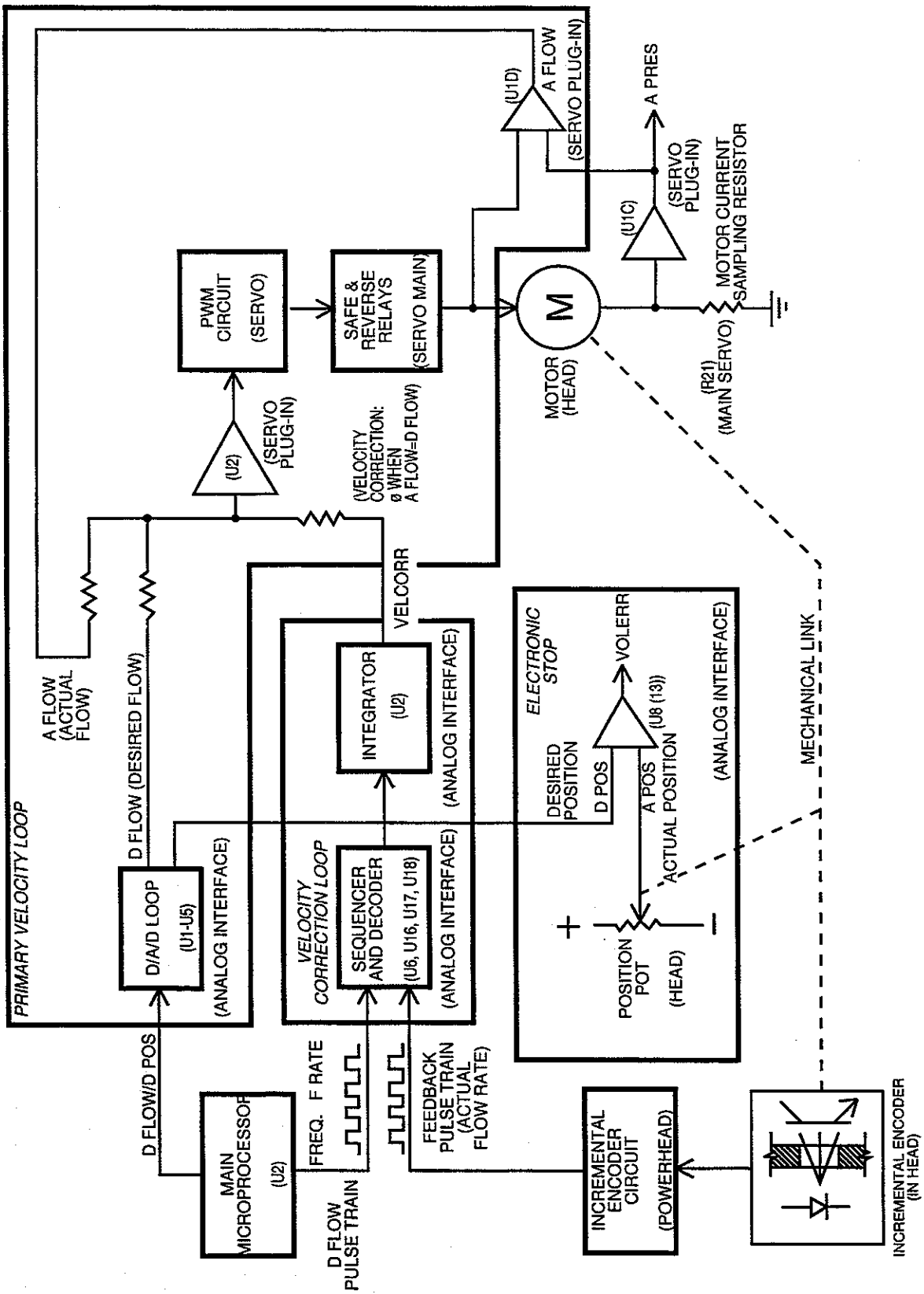


Figure 4-1
System Block Diagram (1 of 2)

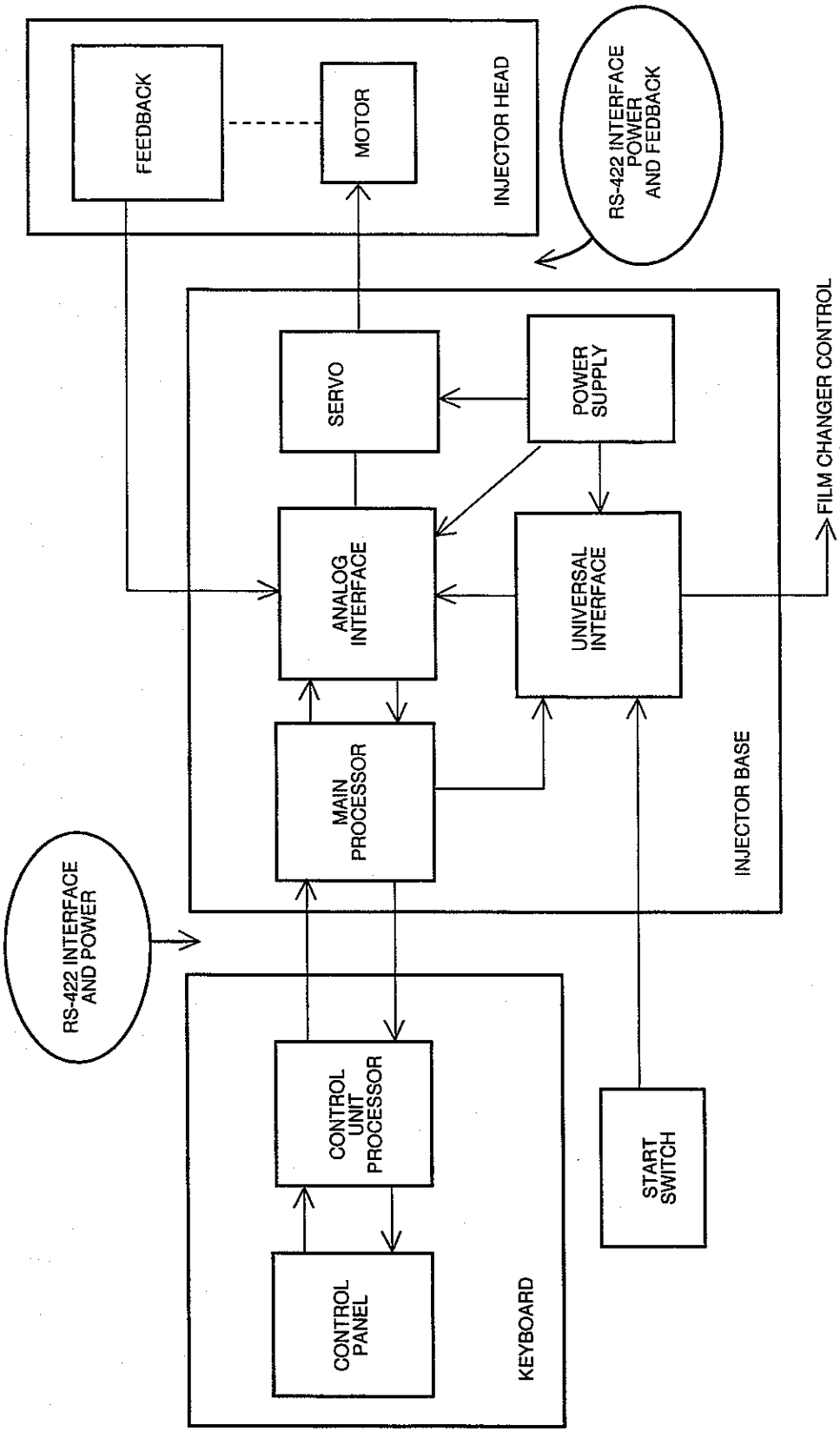


Figure 4-2
System Block Diagram (2 of 2)

KEYBOARD CONSOLE

The keyboard console houses the control panel, system display, and the circuits to support these functions. This allows the operator to program injections, review the results after each injection, and to read messages from the processor.

Major Functions

Through the control panel and system display, the keyboard console provides these major functions:

- Set or change injection variables. The control panel allows selecting (or programming) the values for each injection. These values can be programmed:
  Flow rate — how fast the plunger moves — controls the rate of fluid injected.
  Volume — how far the plunger moves - controls the quantity of fluid injected.
  Transition time — the time to reach the flow rate from the start of the injection, or the time to accelerate or decelerate from one flow rate to another (with special MULTIPHASIC injections) —controls catheter whip.
  Duration — how long the injection runs — is another way to control the quantity of fluid injected.
  Pressure — the limit on the injection force — protects the catheter.
- Status is shown on the system display. The programmed injection values are shown in the system display. LEDs show the selected modes. At the end of each injection, the actual values are shown on the display.
- Messages are shown on system display. The messages guide the operator in the proper setup and tell when there are faults within the system.

Inputs and Outputs

All connections to the keyboard console are through a single connector on the column, wired to the circuits in the base.

The inputs are power for the keyboard console and serial data from the main processor in the base:

Input	From/Function
+ 8.5 VDC	From power supply in base; regulated down to +5 VDC for keyboard console circuits.
RS-422 Serial data	From main processor board in base; status, control, and fault messages.

The output from the keyboard console is the serial data to the main processor in the base:

Output	To/Function
RS-422 Serial data	From main processor board in base; status, control, and programmed settings.

Circuit Description

The circuits in the keyboard console are contained on two circuit boards: the console processor board and the console display board. The console processor board contains the processor, memory chips, control panel and +5 VDC regulator. The console display board contains the system display and its power supply.

+5 VDC Regulator
The regulator chip (U6) receives +8.5 VDC from the main power supply in the base, and provides +5 VDC for all circuits in the keyboard console (except the display panel, which has its own power supply).

Keyboard Console Processor
A microprocessor chip (U5) directs all activity in the control unit. The processor is supported by 2K of RAM (U10) and by the program in ROM (U11). The processor reads the operating program in ROM, reads the status of the keyboard and reads the data from the main processor in the base. The processor controls various LEDs on the control panel and sends status and message data to the system display.

The processor sends data to the main processor through the RS-422 interface.

A 5 MHz crystal (X1) works with the processor's internal clock to synchronize and time activities.

RS-422 Interface
Synchronous data is transmitted between the keyboard console processor and the main processor using RS-422 receivers and drivers. This technique rejects noise and maintains reliable transmission over long cables. One line receiver (U2) in the keyboard console converts the incoming differential data into standard logic levels for the keyboard console processor. Two line drivers (U1A, U1B) convert the logic from the keyboard console processor into differential outputs for transmission to the main processor.

Beeper
A speaker (SP1) and driver (U21A) are controlled by the processor to sound a beep each time a key is pressed on the control panel, and to alert the operator of faults.

Keyboard Console Memory
The processor is supported by 2K of RAM (U10) and 2K of ROM (U11). The operating system is contained on the ROM chip, and the RAM is used for temporary storage of values and conditions.

These chips are connected to an 8-bit data bus and an 11-bit address bus provided by the bus controller. Chip enable lines and read/write logic is controlled by the memory manager.

Bus Controller
The bus controller consists of a bidirectional data buffer (U8), and address latches (U7, U9). The bus controller directs the information flowing in and out of the processor's 8-bit port, provides an 11-bit address bus and an 8-bit data bus, and selects the RAM chip during a read/write cycle.

Memory Manager
The memory manager decodes the enable lines for the read and write cycles, enables the ROM during a read cycle, updates the panel LEDs during a write cycle, controls the direction of data on the data bus and provides a logic line to the display control circuit.

Display Control Circuit
Through a process known as interleaved direct memory access, this circuit reads the data stored in memory only when the processor is not reading or writing data on the bus. This circuit generates signals to drive the display panel.

Console Display
The console display board contains these elements:

Display power supply. Receives +8.5 and +5 VDC from the keyboard console processor board. This flyback supply provides filament power (about 9 VAC) and display voltage (about +40 VDC) for the display panel.

Segment registers. These chips (U38, U35, U47) drive the segments that make up each character on the display panel, controlled by a line from the display data generator (U4) on the processor board.

Character position registers. These chips (U44, U45) energize the character position displayed. They are controlled by lines from the display control circuit on the keyboard console processor board.

Keyboard Circuit
Through the keyboard circuit, the processor knows when keys are pressed. The keys are wired as a matrix with nine columns and four rows. The keyboard scanner (U3) sends a signal to each column of keys one at a time. The four rows that feed back to the processor indicate when a key is pressed. By knowing which column is activated, the processor knows the exact key pressed.

Panel LED's Circuit
The data latches (U12, U13) gate data from the data bus, and are enabled by the control logic (U22A, U22B, U22C). The LEDs show the logic levels at the outputs of the latches.

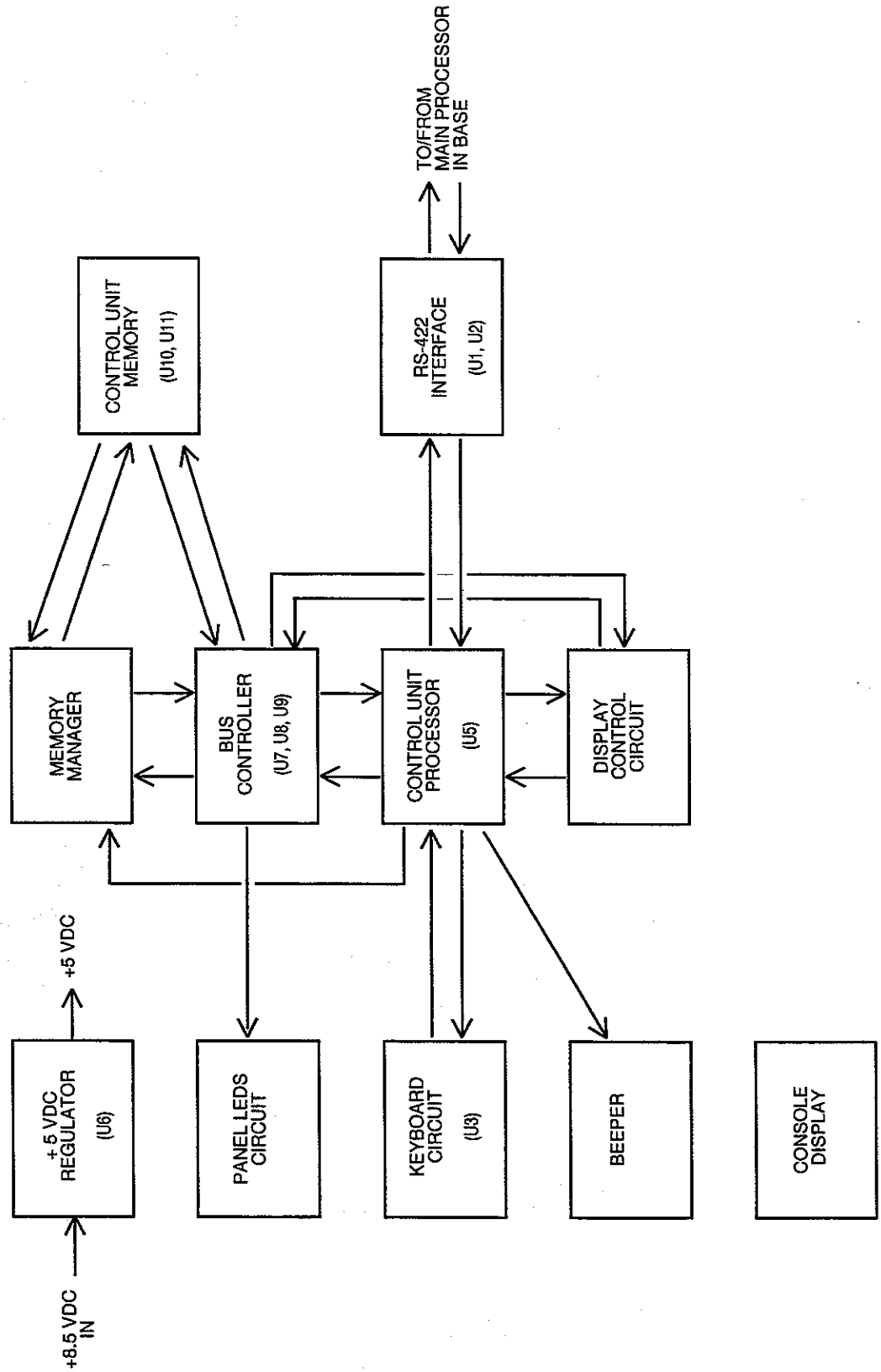


Figure 4-3
Keyboard Console Block Diagram

MAIN PROCESSOR

The main processor provides master control and program execution in the Angiomat 6000. Through its buses, status and control lines, it communicates with all other circuits in the system. Through its RS-422 interface circuit, it communicates with the keyboard console.

As the master director of the system, the main processor provides these functions:

Interface with the keyboard console. Read the injection programmed on the control panel; send setups to the control panel from PPI memory as directed from the control panel; send messages to the system display. Has the option of interfacing with the operator by displaying English, French or German text (chip U12).

Operating system. Provides the sequence of instructions to perform the tasks required of the Angiomat 6000.

Pre-Programmed Injections (PPI). Store the PPI set-ups; send the data to the control panel when requested by the panel through the interface.

Interface with the other circuits. Primarily through the analog interface board, the main processor can read the status of many conditions, and it can control vital activities.

Inputs and Outputs

The inputs allow other circuits to communicate with the main processor for status and control.

Input	From/Function
+ 8.5 VDC	From power supply; regulated down to +5 VDC for processor circuits.
RS-422 Serial data	From processor in keyboard console; status, control, and fault messages.
Data bus	From analog interface; 8-bit data bus allows bi-directional data exchange.
Parallel I/O	From analog interface; allows the processor to read status of many conditions.
Control lines	From various circuits; allow other circuits direct access to the processor.

The outputs from the main processor allow it to communicate with the keyboard console and the analog interface board:

Output	To/Function
RS-422 Serial data	To processor in keyboard console; for transmission of data.
Data bus	To analog interface; 8-bit data bus allows bi-directional data exchange.
Parallel I/O	To analog interface; allows the processor to control many conditions.
Control lines	To various circuits; allows direct control by the processor.

Circuit Description

The main processor board contains the processor, its clock and watchdog circuits; memory chips for the main memory; PPI circuits; control and logic circuits; interface circuits; and +5VDC regulator.

+5 VDC Regulator
The regulator chip (U27) receives +8.5VDC from the main power supply and provides +5VDC for circuits on the main processor board.

Main Processor
A microprocessor chip (U1) directs all activity in the Angiomat 6000. The processor supported by 8K of RAM U3 and the program on EPROM U7. The processor reads the operating system program and stores temporary settings and conditions in RAM. Data flow in and out of memory and the I/O ports is controlled by logic and address decoders.

A 5 MHz crystal (XTL2) generates the processor's internal clock to synchronize and time activities.

The watchdog (U16) guards the processor. If the Watchdog does not receive a pulse from the processor every 10 msec, it resets the processor and the versatile interface adapter (U4), causing a "watchdog reset error" that interrupts the injection. This interruption disables the servo, opens the safe relay, and sets all parameters to zero.

The processor communicates with the keyboard console through the RS-422 interface and with the analog interface board through its I/O interface.

Language
Chip U12 on the Main Processor board contains all text information that is forwarded to the console for display. This text can be display in English, German or French. The default configuration for the unit is English. German and French can be displayed by changing the configurations of jumpers JP1 and JP2. Configure the jumpers in accordance with the following table in order to meet your specific needs.

Language	JP1	JP2
English		
German	connected	
French		connected

RS-422 Interface
Synchronous data is transmitted between the processor and the keyboard console using RS-422 receivers and drivers. This technique rejects noise and maintains reliable transmission over long cables. Two line receivers (U14A, U14C) on the main processor board convert the incoming differential data into standard logic levels for the processor. One line driver (U15C) converts the logic from the processor into differential outputs for transmission to the keyboard console.

Watchdog
If the watchdog (U16, Q3) does not receive a pulse from the processor every 10 msec, it resets the processor and the versatile interface adapter (U4), causing a "watchdog reset error" that interrupts the injection. This interruption disables the servo, opens the safe relay, and sets all parameters to zero.

Main Memory
The processor is supported by 8K of RAM (U3) and 32K of EPROM (U7). Enable lines and read/write lines are controlled by logic and address decoders.

Bus Control
The bus control consists of a bidirectional data buffer (U5), address latch (U2), and an I/O address decoder (U6/U9 gates). The bus control directs the information flowing in and out of the processor's 8-bit port, and provides an address bus and an 8-bit data bus.

Memory Manager
The memory manager decodes the addresses to enable the memory chips for the main system.

I/O Interface
A versatile interface adapter (U4) allows the processor to communicate with circuits on the analog interface board. Through the address bus the processor can select the I/O lines connected to this device, to gate data on and off the data bus. This device also contains timers to coordinate activity.

I/O Control
This tells the selected circuit or device it can send data to the processor on the data bus.

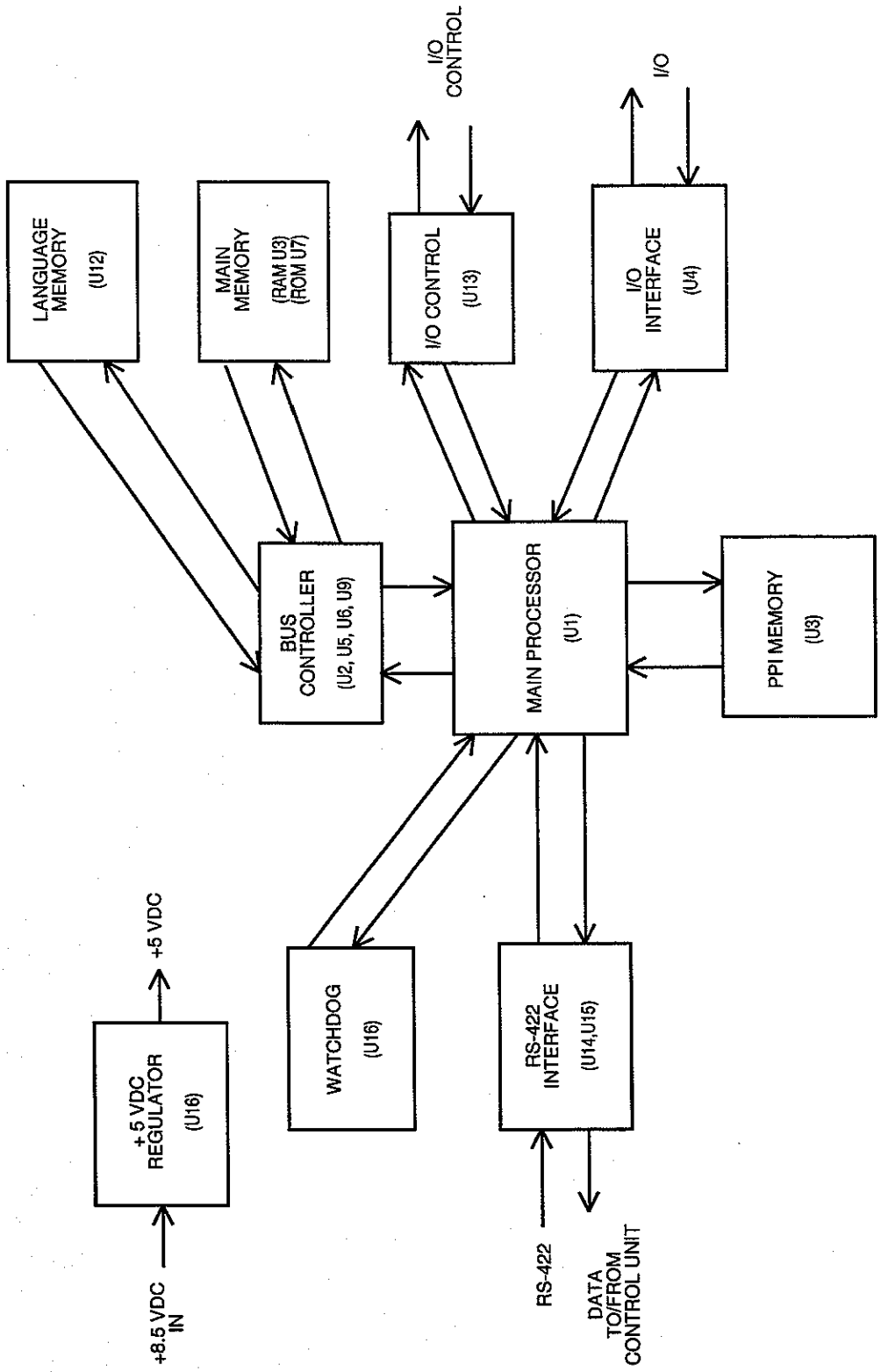


Figure 4-4
Main Processor Block Diagram

ANALOG INTERFACE

The analog interface ties the Angiomat 6000 system together. It communicates with the main processor over the data bus and through the parallel I/O ports. It communicates with the powerhead over RS-422 lines. The analog interface sends commands to the servo to control the motor, while feedback from the servo and powerhead shows the results, which are reported to the main processor.

The analog interface performs these functions:

- Transforms the main processor's digital commands into analog commands for the servo to control velocity, position, and pressure.
- Communicates with the powerhead and servo to derive actual velocity, position, and pressure.
- Compares desired commands to actuals, and adjusts the servo commands.
- Converts the actuals to digital data for the processor.
- Detects failures in interfaces, feedback, and performance.

Inputs and Outputs

The analog interface has inputs and outputs with the processor, servo, powerhead, and universal interface.

Input	From/Function
+ 8.5 VDC	From power supply; regulated down to +5 VDC for analog interface circuits.
10 VAC	From power supply; for powerhead light circuit.
RS-422 Serial data	From powerhead; data provides velocity and volume feedback, and status of several conditions.
Position pot	From position pot in powerhead; wiper signal shows plunger position.
Data bus	From main processor; 8-bit data bus allows bi-directional data exchange.
Parallel I/O	From main processor board; allows the processor to control many conditions.
Motor signals	From servo; voltage and sampled current signals proportional to actual velocity and pressure.
Status and error signals	From servo; to fault detectors in analog interface; indicate servo state, servo power failure, safe relay not closed, and over-temperature.

Actuals	From servo; signals proportional to actual flow rate, actual pressure.
Pressure signals	From servo; tell when pressure limiting is occurring and when backup pressure circuit is being used.
Start signal	From standard interface; signals when hand start switch is closed.
Remote start signal	From standard interface; signals when remote start switch (connected to J) is closed.

Output	To/Function
RS-422 powerhead clock	To powerhead; clock pulses to synchronize the data transmitted back to the analog interface.
Position pot reference	To position pot in powerhead; this reference voltage connects to the ends to the pot; wiper feeds back plunger position.
Indicator lamps	To powerhead; powers ENABLED and INJECTING lights.
Control lines	To main processor; allow direct access to the processor.
Drive signals	To servo; control magnitude of power supplied to motor, thereby controlling velocity and pressure; duration controls volume.
Drive control	To servo; enables and disables the servo circuits.
Reverse relay	To servo; to energize the reverse relay; changes the motor polarity for reverse motion.
Brake signal	To servo; to turn on the brake at the end of an injection.

Circuit Description

Basically, the analog processor takes the digital commands from the main processor, compares them to the actual values, and sends drive signals to the servo to control the motor.

+5 VDC Regulator
The regulator chip (VR1) receives +8.5 VDC from the main power supply and provides +5 VDC for circuits on the analog interface board.

2-Port Memory
The 2-port memory (U9, U22) allows data to be read from the main processor's data bus for the digital (D-to-A) converter.

D-to-A Converter
The D-to-A converter (U21) receives digital data from the 2-port memory and converts it to a proportional analog level. This output is buffered (U20) for the analog demultiplexer. Four values are converted in series for desired flow, pressure, position and manual ECG Trigger gain. Because all three signals are presented on one line, they need to be demultiplexed.

Analog Demultiplexer
The analog demultiplexer (U31) converts the three signals on one line from the D-to-A converter into three separate outputs.

Analog Storage
The outputs from the analog demultiplexer charge capacitors (C12-C15) which are buffered (U32) so they hold the charge. The buffered outputs change as the signals from the demultiplexer are refreshed. The signals from the analog storage are the desired flow, pressure and position. These are used as references by circuits on the analog interface and on other boards.

A-to-D Converter
When enabled by a write signal from the main processor, the A-to-D converter (U33) changes the analog signals back to digital data. When enabled by a read signal from the main processor, the A-to-D's output is read to the data bus. The main processor compares the data coming back to the data sent to the D-to-A converter. If the data doesn't match, there is a problem in the conversion loop. If this happens, the main processor disables the injector, and flashes a message on the system display.

The A-to-D converter also reads the actual position, pressure, motor current and ECG Trigger gain output and converts these to digital data for the main processor.

Reference
The reference circuit (U19, U17 pin 1, U7 pin 14 and U1 pin 8) provides fixed voltages to the converters, charge pump and position pot in the powerhead.

Non-Overlap Clock
This circuit eliminates cross-talk during conversion.

Position Pot
This precision device in the powerhead is mechanically linked to the plunger. A reference voltage is applied to the ends of the pot, and the wiper feeds back a voltage proportional to the plunger's position. This is used to derive actual plunger position.

Pot Buffer
The pot's wiper is buffered (U7 pin 8) to prevent loading and to filter noise.

Pot Error Processor
A comparator (U8 pin 1) monitors the actual position signal. If it exceeds preset limits, as it will if the wiper connection opens, a pot error signal is sent to the hard error latch and to the error gate.

Pot Error Comparator
The comparator (U8 pin 13) looks at the actual and desired positions. If the actual position gets ahead of the desired position, a volume error signal is sent to the hard error latch and to the error gate.

Powerhead Interface
A clock signal is generated to synchronize the data transmitted from the powerhead to the analog interface. An RS-422 driver (U34) sends the Clock signal to the powerhead, while an RS-422 receiver (U30) accepts the synchronous data. These RS-422 devices reject noise and maintain reliable transmission over long cables.

Powerhead Clock. For proper synchronization of the data, a unique clock signal is generated (U28, U26, U25) .

Data Register. This shift register (U35) converts the serial pulse train from the powerhead into parallel pulses for the data latch.

Data Latch. This device (U27) receives the parallel pulse from the data register and holds the powerhead data so it can be read by the processor and other circuits.

Postamble Detector. To insure reliable transmission, each data chunk from the powerhead includes a postamble; a 4-pulse signal at the end of the data. One device compares the postamble from the powerhead to the desired code. If they don't match, this detector puts out signals to the powerhead status register (to alert the main processor) and to the error detector (U28), which sends out a powerhead error signal to disable the injector.

Powerhead Status Register. This shift register (U23) receives data that shows the status of several items in the powerhead. When enabled by a read signal from the main processor, the register's output is read to the data bus.

Direction Decoder
Using the phase signals from the position encoder in the powerhead, these devices (U17, U18) tell which direction the plunger is moving. Their outputs control the charge pump and trip the directional latch. If the incoming data is invalid, an error signal is sent to the quadrature error latch.

Direction Latch
This flip-flop (U15) sends a direction signal to the status buffer (U10). The direction signal tells which way the plunger is moving. This signal can be gated to the data bus when requested by the main processor.

Pulse Sequencer
These devices (U6, U16) generate a sequence of pulses to charge or discharge the charge pump, depending on whether the actual velocity (from the position encoder in the powerhead) leads or lags the desired velocity.

Pulse Width Adjuster
This circuit (U6, U16) makes sure the pulses going to the charge pump are the same width, for controlled charging and discharging.

Charge Pump
This integrator (U2) charges and discharges to generate a velocity correction signal for the servo. To increase the drive, a solid-state switch (U3) closes to increase the output of the charge pump. To decrease the drive, another switch (U3) closes to decrease the output.

The charge pump can be reset from the main processor between injections. If pressure limiting occurs, a circuit (Q1-Q3) opens the charge pump's input circuit to reduce the drive.

Nonlinear Amplifier
This amplifier (U1 pin 7) has less gain for small signals, more gain for larger signals. The gain increases as the difference increases between the actual and the desired velocity. It causes the servo to be more responsive as the discrepancy increases.

-V Reference
This unity-gain inverter (U1 pin 8) provides a reference voltage for the charge pump and the nonlinear amplifier.

Sync Error Detector
If the signal from the nonlinear amplifier is significantly different than the command, this comparator (U1) sends a sync error to the hard error latch and the error gate.

During the power-up tests, this comparator is tested by a read error signal from the main processor.

Error Gate
This gate (U5) receives seven lines that can signal errors. If any line sends an error signal, this gate trips the error delay which in turn stops the servo and advises the main processor.

Error Delay
When the error gate detects an error, this device (U13) delays the signal by 20 msec, then trips the error occurred latch (U14).

Error Occurred Latch
When given the signal from the error delay (U13), this latch (U14) trips and sends a signal to the servo to stop the motor and sends a signal to the main processor to advise of a failure.

A failure in the powerhead data can also trip this latch. If the postamble doesn't match the code, a detector (U28, U25) sends a powerhead error signal to the error occurred latch.

Hard Error Latch
Eight lines are received by this latch (U4) that can signal errors. If an error occurs, a signal from the error occurred latch causes the hard error latch to hold the data into it. When requested by a read signal from the main processor, the data into this latch is transferred to the data bus.

Clock Generator
This device (U12) generates several clock signals for circuits on the analog interface board.

Pressure Error Detector
This comparator (U8 pin 14) generates an error signal if the actual pressure exceeds the desired pressure.

Flow Difference Amplifier
The output of this comparator (U7 pin 7) is the difference between the desired flow rate and the actual flow rate. This signal is used by the servo to control the motor speed, and by the flow error detector to check for flow rate errors.

Flow Error Detector
When the flow difference signal is significant, this comparator (U8, pin 2) sends a flow error to the hard error latch and the error gate.

Powerhead Indicator Control
Signals from the main processor control the ENABLED and INJECTING lights in the powerhead. A bidirectional diode (Q6) controls the polarity of the voltage sent to the powerhead, switched from 10 VAC from the power supply. Diodes in the powerhead steer the power to the lights in the powerhead.

Start Receivers
Hand start switch commands from the Universal Interface are received (U30) on the analog interface board and sent to the main processor board (U25).

Remote start commands from the Universal interface are received (U30) on the analog interface board and sent to the main processor board (U25).

Status Signals Buffer
This device (U10) receives eight signals from the powerhead, servo, and other analog circuits. When requested by a read line from the main processor, the data in this buffer is read on the data bus.

Quadrature Error Latch
If quadrature error is detected by the direction decoder (U17, U18), this latch (U14) sends a signal to the status signal buffer. A signal sent to the servo stops the motor.

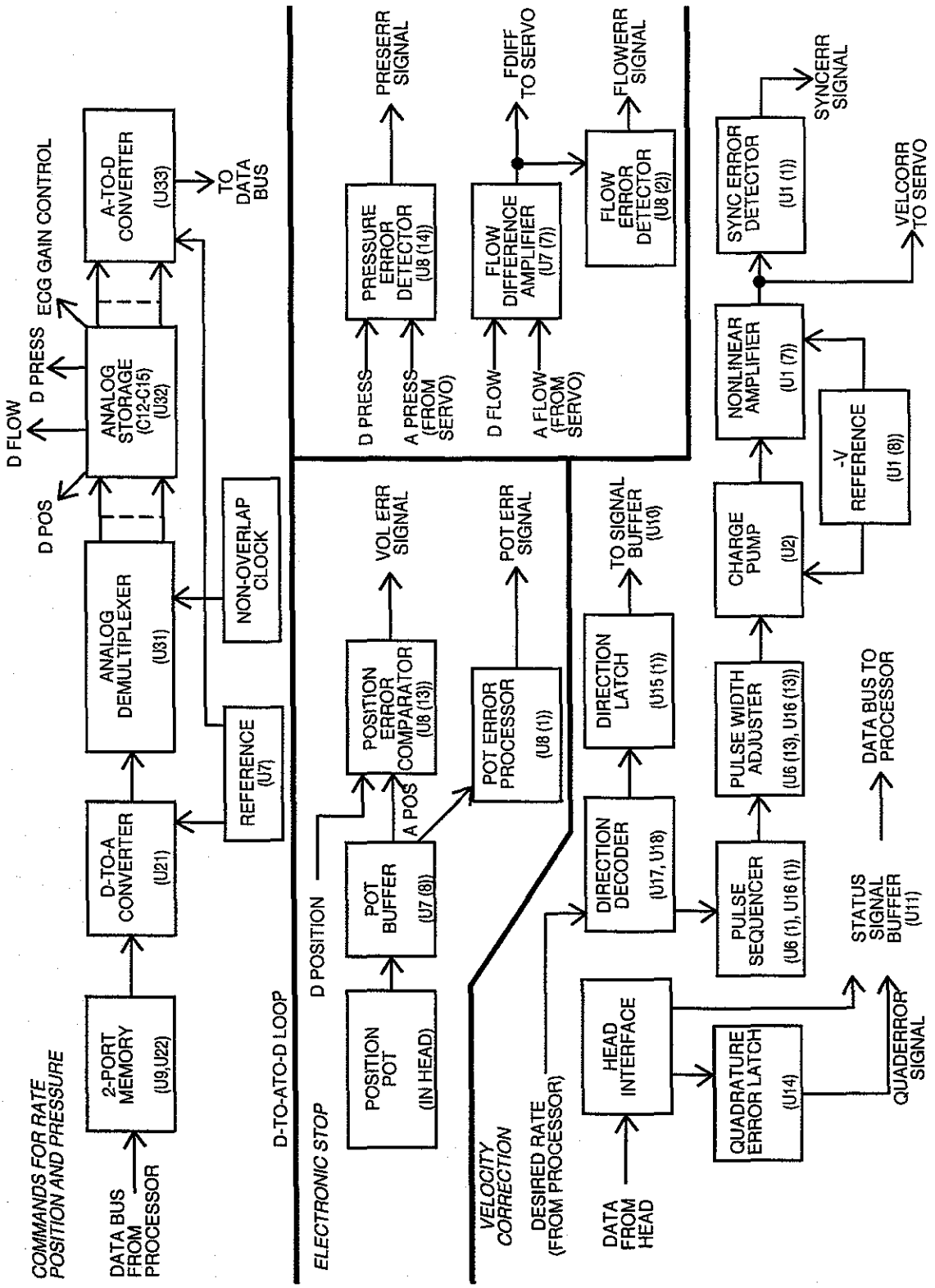


Figure 4-5
Analog Interface Block Diagram (1 of 2)

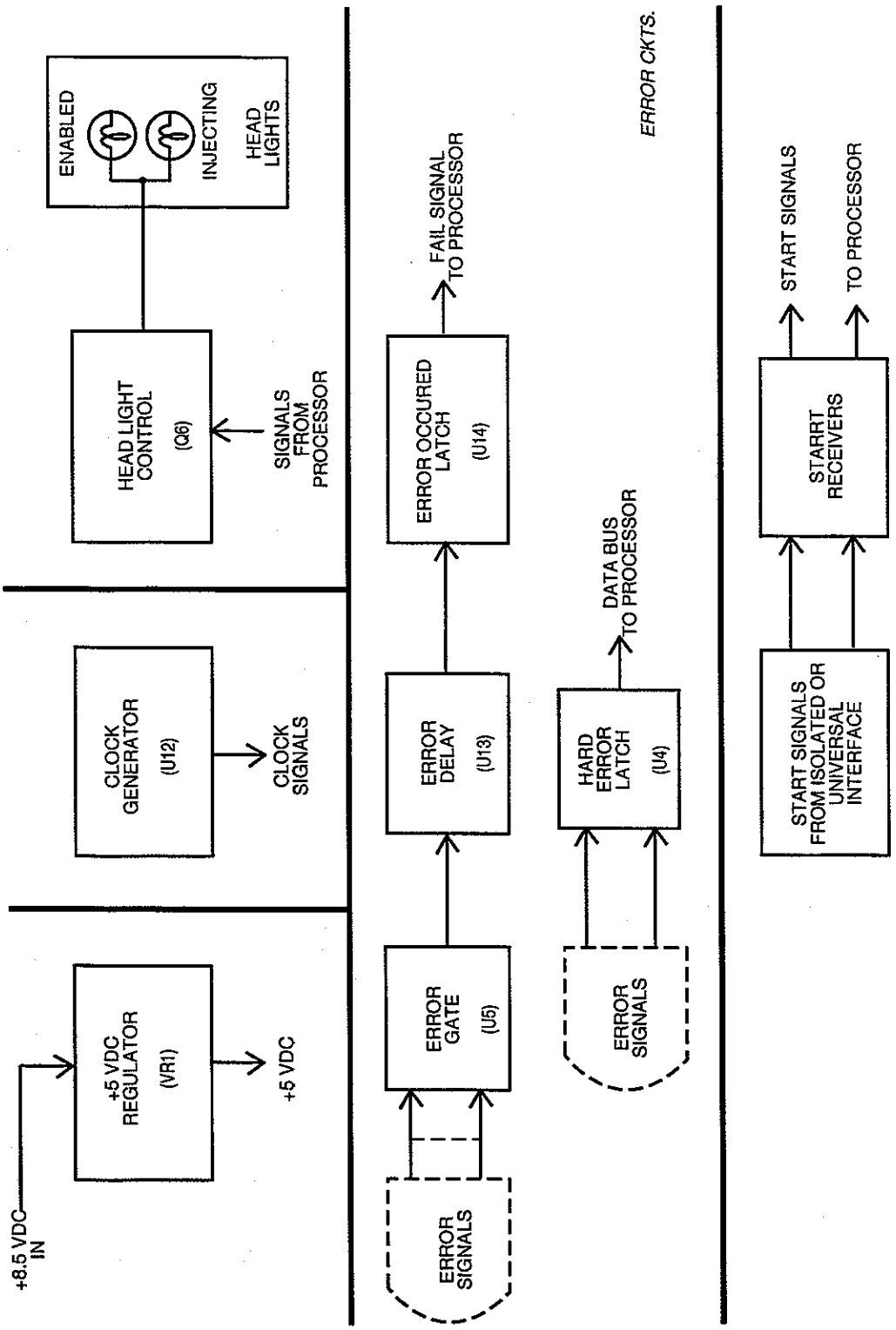


Figure 4-6
Analog Interface (2 of 2)

SERVO

The servo system is an off-line switcher and velocity control loop that accepts commands from the main processor, and controls the power supplied to the motor.

The servo is controlled by the difference between the desired flow rate command and the actual velocity based on the motor's back-EMF. This is the main velocity control loop. A second loop provides velocity correction for zero steady-state velocity error.

If the velocity correction signal gets too great, a hardware error trap stops the injection (this would be a sync error).

The servo drives the motor through pulse-width modulation. Power output is controlled by varying the duty cycle of the output switching devices.

The servo is contained on three boards: The main servo board, a smaller board that plugs into the main board, and a servo top board that contains the main power supplies. The plug-in board contains the control and logic circuits, while the main board contains the power-handling components.

In turn, the plug-in board communicates with the powerhead transmitter board in the powerhead.

Major Functions

Basically, the servo causes the motor (in the powerhead) to turn, moving the plunger. Other circuits control this motion through the servo, and the servo provides information back to these circuits to maintain precise control.

A summary of the major functions of the servo:

- Generate power for the motor.
- Allow processor and analog interface to control motor power, thereby controlling flow rate, volume, and pressure.
- Supply motor voltage and current signals, used by the analog interface to derive actual velocity and pressure signals.
- Allow detected errors to stop motor.
- Provide a fail-safe way for the main processor to enable and disable the injection through the safe relay.
- Allow reverse motion.
- Provide brake function; stop injection at the end of the injection for accurate volume delivery without recoil.

Inputs and Outputs

Inputs to the servo control the motor's speed, position, and on- time, thus controlling flow rate, volume, and duration. Outputs from the servo are proportional to the actual flow rate and pressure. A summary of the servo's inputs and outputs:

Input	From/Function
Switched AC line	From power cord and power switch; for line-driven motor drive circuit.
Drive signals	From analog interface; to control magnitude of power supplied to motor, thereby controlling velocity and pressure; duration controls volume.
Drive control	From analog interface; to enable and disable the servo circuits.
Safe relay enable	From processor; square wave signal to energize safe relay.
Reverse relay	From analog interface; to energize the reverse relay; changes the motor polarity for reverse motion.
Brake signal	From analog interface; to turn on the brake at the end of an injection.

Output	To/Function
Motor power	Drive power to motor; magnitude sets velocity (flow rate) and pressure;duration sets volume.
Motor signals	Voltage and sampled current to analog interface; proportional to actual velocity and pressure.
Status and error signals	To fault detectors in analog interface; indicates servo state, servo power failure, safe relay not closed and over-temperature
Actuals	To analog interface; signals proportional to actual flow rate, actual pressure.
Pressure signals	To analog interface; determines when pressure limiting is occurring and when backup pressure circuit is being used.
Switched AC line	To power supply; for main supplies.
Switch AC line	To standard interface; for isolated supply.
Brake signal	To servo; to turn on the brake at the end of an injection.

Circuit Description

The switched AC line is applied to the servo-top board, and from there goes to these places:

- The line is fused (FU1) and filtered (LF1), then goes to the power transformer and the universal interface board.
- The line is fused (FU2), protected (MOV1) and filtered (TR1, C1, C2). The line is switched (Q1), thermal protected (TS1), rectified (BR2), further filtered (C6 - C9, L1 - L3) and fused (FU3), then supplied to the driver output stage.
- The line also powers the +35 VDC supply.

Power Control
A thermal switch (TS1) opens if the drive draws too much power from the line, overheating a resistor (R1) in series with the line.

Power to the drive output stage is controlled by a solid-state switch (Q1), driven by one side of an optical isolator (U1). The isolator will turn on the switch when the +35 VDC supply is above a certain threshold. Therefore, when power is turned on, the enable switch (Q1) will be off until the +35 VDC supply stabilizes.

+35 VDC Supply
The base driver stage, which controls the output stage, uses the +35 VDC supply contained on the servo board. The +35 VDC supply is comprised of a line-operated transformer (TR2), rectifier (BR1), filter (C3) and regulator (Q10, Q12).

The +35 VDC line is monitored by U1. If the voltage fails, the optical isolator (U1) turns off the power control circuit (Q1) to interrupt line power to the drive output. If the +35 VDC line fails, a signal is also sent to the analog interface.

PWM Control
The pulse-width modulation (PWM) control circuits are contained on the small board that plugs into the large servo board. The main element is the modulation control chip (U2). It receives drive and control signals from the analog interface and provides duty-cycle control (Q2 - Q4) to the primary of a transformer (TR4).

Power Stage
The secondary of the transformer (TR4) drives the output stage (Q2-Q6, Q9) to switch power to another transformer (TR1). Its secondary is rectified (BR3), filtered (L5, C17, TR3, C18-C20) and fused (FU4) to become the drive power to the motor.

Safe Relay
The safe relay (RLY1) must be closed for servo power to be connected to the motor. The enable signal is a square wave from the main processor board. This signal causes the safe relay driver circuit (Q7, TR5) to ener-

gize the safe relay to close the servo-to-motor loop. The signal is transformer coupled, so if the incoming signal is a DC level, or if this circuit locks up, the relay will stay open and an injection will not occur.

If the safe relay enable signal is missing or if it is a DC level, a sensing circuit (Q13) sends a fault signal to the analog interface.

Reverse Relay
The reverse relay (RLY2) is controlled by a relay driver (Q8). When the motor is to turn in reverse, a signal from the analog interface turns on the relay driver to energize the relay. This reverses the connections to the motor to change its direction.

Brake Switcher
The brake switcher (Q11) shunts the motor drive line at the end of an injection.

Current Sampling Resistor
A resistor (R21) in series with the motor drive lines provides a signal proportional to motor current. This is used by the analog interface to derive actual pressure. If this resistor overheats, a thermal sensor (TS1) sends a signal to the analog interface to stop the injection.

Current Sense Amplifier
This circuit (U1C) receives the signal from the pressure sampling resistor (R21), derives the actual pressure signal for the PWM control circuit and the analog interface and derives the motor current signal for the analog interface.

Pressure Limit Follower
The inputs to this circuit (U1A) are the desired pressure and actual pressure. While the actual pressure stays below the desired pressure, this circuit has no effect. But when the actual pressure starts to exceed the desired pressure, this circuit becomes a follower with a gain of one. This pressure limit signal is used to limit the velocity error signal.

Backup Pressure Sampler
As a backup to the primary pressure circuit, a transformer (TR2) provides a signal proportional to the drive power. This is used by the analog interface to derive actual pressure if the primary pressure circuit fails.

Backup Pressure Circuit
This circuit (Q6, U1 B) receives signals from the backup pressure transformer (TR2) on the servo. Backup pressure signals are derived and fed to the PWM controller (U2), and to the analog interface to indicate the system is using the backup.

Actual Flow Circuit
This circuit (U1D) receives motor voltage and current signals, and derives the actual flow rate signal for the analog interface.

Enable Logic
This circuit (U3 gates) receives control signals from the analog interface to enable the PWM control and brake drive.

Brake Drive
This circuit (U4) controls the servo brake to cut power to the motor.

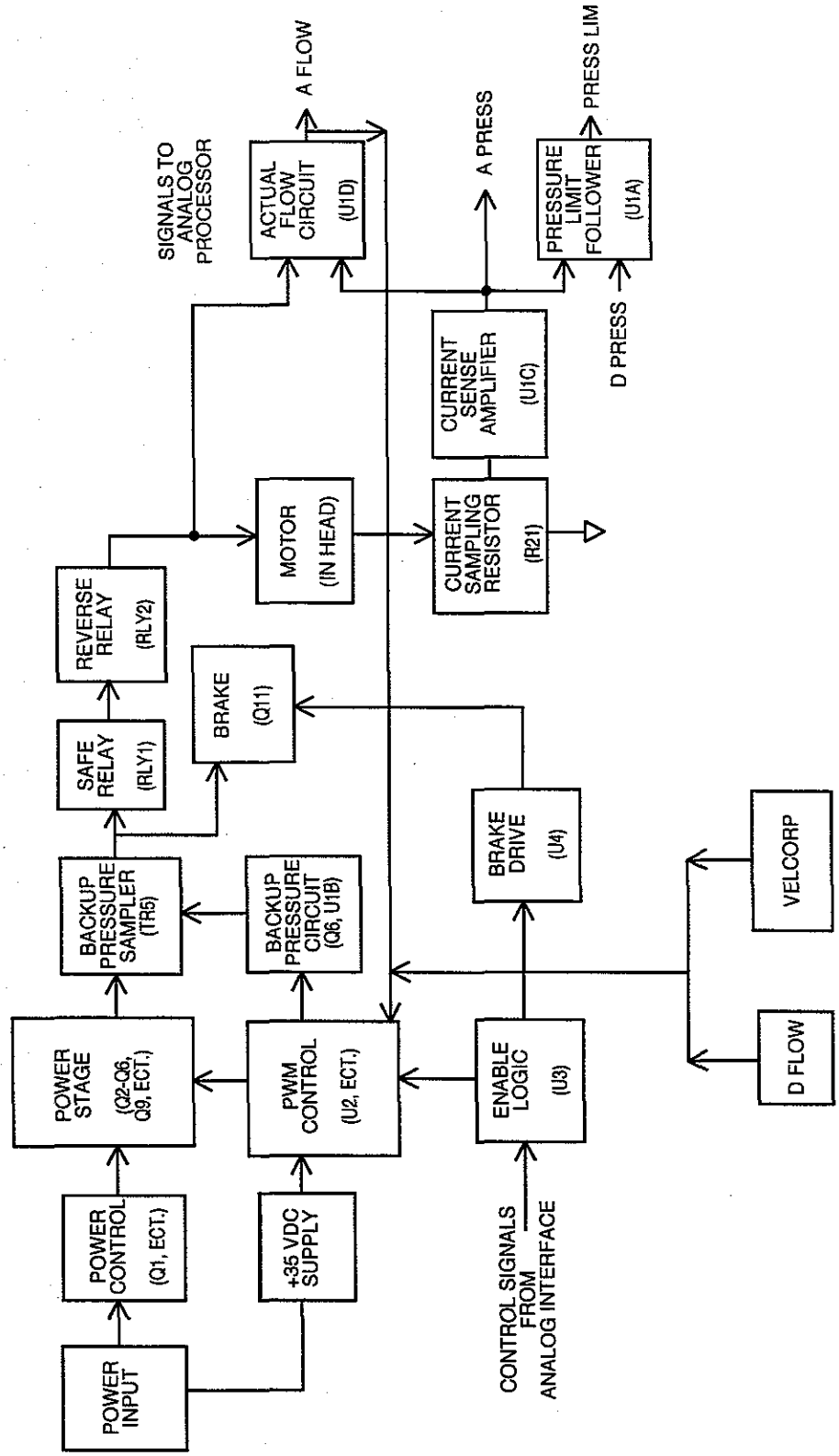


Figure 4-7
Servo Block Diagram

POWERHEAD

The powerhead holds the syringe and plunger, and contains an electric motor, gear train, and ballscrew to drive the plunger forward and reverse. An encoder and potentiometer provide feedback to the analog interface about the actual velocity and position of the plunger. These and other functions are described in this section.

Major Functions

Basically, the powerhead drives the syringe plunger so fluid can be injected. The powerhead also allows syringes to be loaded, and keeps loaded syringes warm. In addition, signals must be constantly sent back to the analog processor about the powerhead's status. The powerhead serves these functions:

- To drive the syringe plunger, the powerhead transforms electrical power into rotary motion with a motor, then into linear motion with a ballscrew assembly.
- To keep track of the plunger's velocity and position, the powerhead contains two feedback devices: a potentiometer and an optical encoder.
- For other information needed by the keyboard console, the powerhead contains sensors for the syringe size in use; optical limit switches indicate when the plunger is in one of its end-of travel limits; and a tilt switch tells when the powerhead is tilted up or down.
- The powerhead contains a control panel to show the syringe size and volume remaining; to show when the system is enabled and injecting; and to show when a fault has been detected.
- Pushbuttons allow the operator to move the plunger forward or reverse for loading. A knob moves the plunger to remove air or position the plunger.
- Circuits in the powerhead transmit data to the keyboard console about all the above functions. The transmission format is RS-422. The integrity of this connection is constantly being checked by circuits in the analog interface.
- A heater assembly maintains the temperature of the fluid in the syringe through a temperature-controlling circuit in the powerhead.

Inputs and Outputs

All connections to the powerhead are made through the cable connected to the analog interface in the base. These are the powerhead's inputs and outputs:

Input	From/Function
Motor power	From servo; drives motor forward or reverse.
20 VAC/CT	From power supply; used in powerhead to derive +5 VDC and heater power.
RS-422 powerhead clock	From analog interface; clock pulses to synchronize the data transmitted to control unit.
Position pot reference	From analog interface; reference voltage to ends of position pot; wiper feeds back plunger position.
Indicator lamps	From analog interface; powers ENABLED and INJECTING lights.

Output	To/Function
RS-422 serial data	To analog interface; data provides velocity and volume feedback and status of several conditions.
Position pot	To analog interface; pot's wiper shows plunger position.

Circuit Description

Multiplexer

Shift registers (U2, U3) receive multiple inputs and convert them to a pulse train. The high or low state of the pulses in the train shows the status of these inputs:

Phase 1 and Phase 2. The chopper wheel, mounted to the motor's shaft, controls the signals provided by the optical encoder (U1), and transformed (by Q1 - Q4) into phase signals. These signals are used in the keyboard console to derive the speed and direction of the motor.

Forward and Reverse Load Keys. These signals show when these keys are depressed. This is used by the injector to accelerate the motor to the standard loading rate.

Fast Key. Located between the Forward and Reverse Keys, when depressed will increase the speed of plunger in either direction up to 25 ml/s.

Syringe Size. The syringe plate activates a switch to show what size syringe is being used. This lights an LED on the control panel and provides a size signal to the shift register.

Tilt. A tilt switch in the powerhead tells when the powerhead is pointing up or down. This is used in the injector as part of the loading and air expulsion protocol.

Heater Over temperature. When this condition occurs, the heater circuit drives one side of an optical coupler (U9). The other side of the coupler sends an over temperature signal to the shift register.

Limit Switches. When the plunger reaches its end-of-travel limits, optical sensors (U4, U5) send signals to the shift register.

Postamble. To insure reliable transmission, each data chunk from the powerhead includes a postamble: a 4-pulse signal at the end of the data. The analog interface compares the postamble from the powerhead to the desired code. If they don't match, the main processor is advised of a fault, and the injector is disabled.

RS-422 Interface
A clock signal is generated in the analog interface to synchronize the data transmitted from the powerhead to the control unit. A line receiver (U6) extracts the clock signal for use by the shift registers. A line driver (U7) sends the synchronous data from the shift registers to the keyboard console. These RS-422 line receivers and drivers reject noise and maintain reliable transmission over long cables.

Synchronizer
This circuit (U8E, U8F) synchronizes the data shifted from one register (U2) to the other (U3).

Feedback Potentiometer
The feedback potentiometer provides a signal proportional to the plunger's position. A reference voltage from the analog interface is connected to the ends of the pot. The pot's wiper, which is mechanically tied to the motor to move with the plunger, feeds back the position signal. Circuits in the analog interface check the integrity of the feedback signal; if the signal is lost, a fault is detected to stop the injector.

Indicator Lamps
Two lights on the powerhead show the system's status:

ENABLED Light. When the system is enabled, this lights; when disabled, this light is out.

INJECTING Light. While the system is injecting, this lights solid. When in standby, this light is out. If a major fault is detected, this light flashes.

These lights are driven by one line (from the analog interface) and ground. To light *ENABLED,* the line goes positive. To light *INJECTING,* the line goes negative.

Powerhead Power
Low-voltage AC from the power supply is rectified (D4, D5, BR1), filtered (C4, C5, C8) and regulated (VR1) for the powerhead circuits and the syringe heater.

Syringe Heater
The syringe heater is a flexible blanket that fits over the pressure jacket to maintain the temperature of the contrast medium in the syringe. The heat controller, on a circuit board in the powerhead, supplies power to the heater and monitors its temperature to keep the contrast from overheating. If overheating occurs, the heater controller turns on one side of an optical coupler (U9) in the multiplexer circuit. The other side of the coupler sends an over temperature signal to one of the shift registers (U3) so it can be transmitted to the analog interface in the base.

Heater Circuit Press-to-Test Button
The high-limit temperature sensor detects any overheat condition caused by malfunction of the control circuitry. When an overheat occurs, a warning buzzer sounds. On domestic units, the signal can be silenced by removing the heater blanket modular plug from the powerhead connector. The operator can continue to use the injector but the contrast will not be warmed. On international units, a representative from service must be notified in order to correct the problem.

The powerhead has a "Press-to-Test" button for the heater blanket control circuit. Pressing the button simulates an overheat condition. The sensor then detects the "overheat" and sounds the warning buzzer. To be assured that the control circuit is functioning properly, perform the tests outlined in Chapter 6, Installation and Checkout.

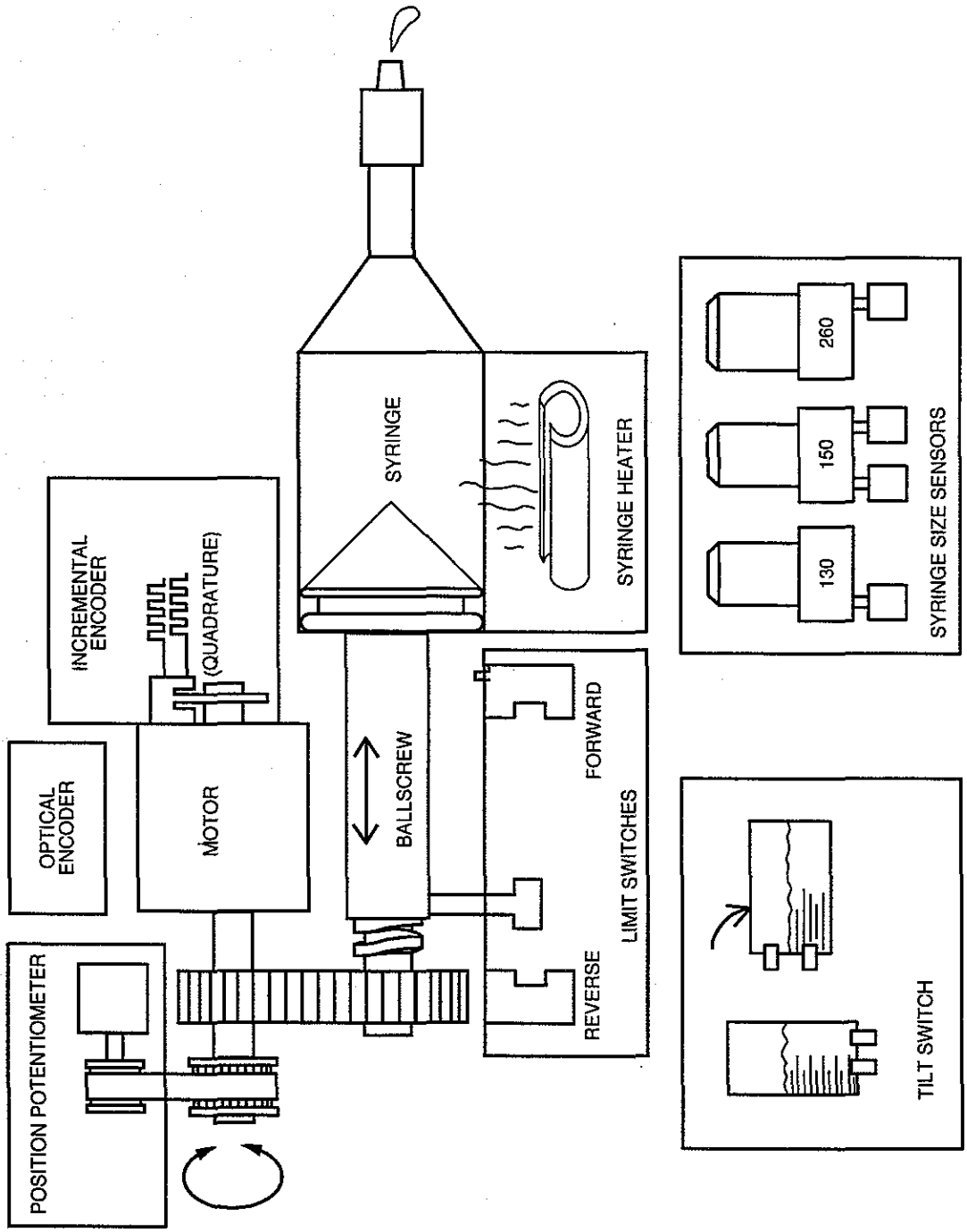


Figure 4-8
Powerhead Functional Diagram

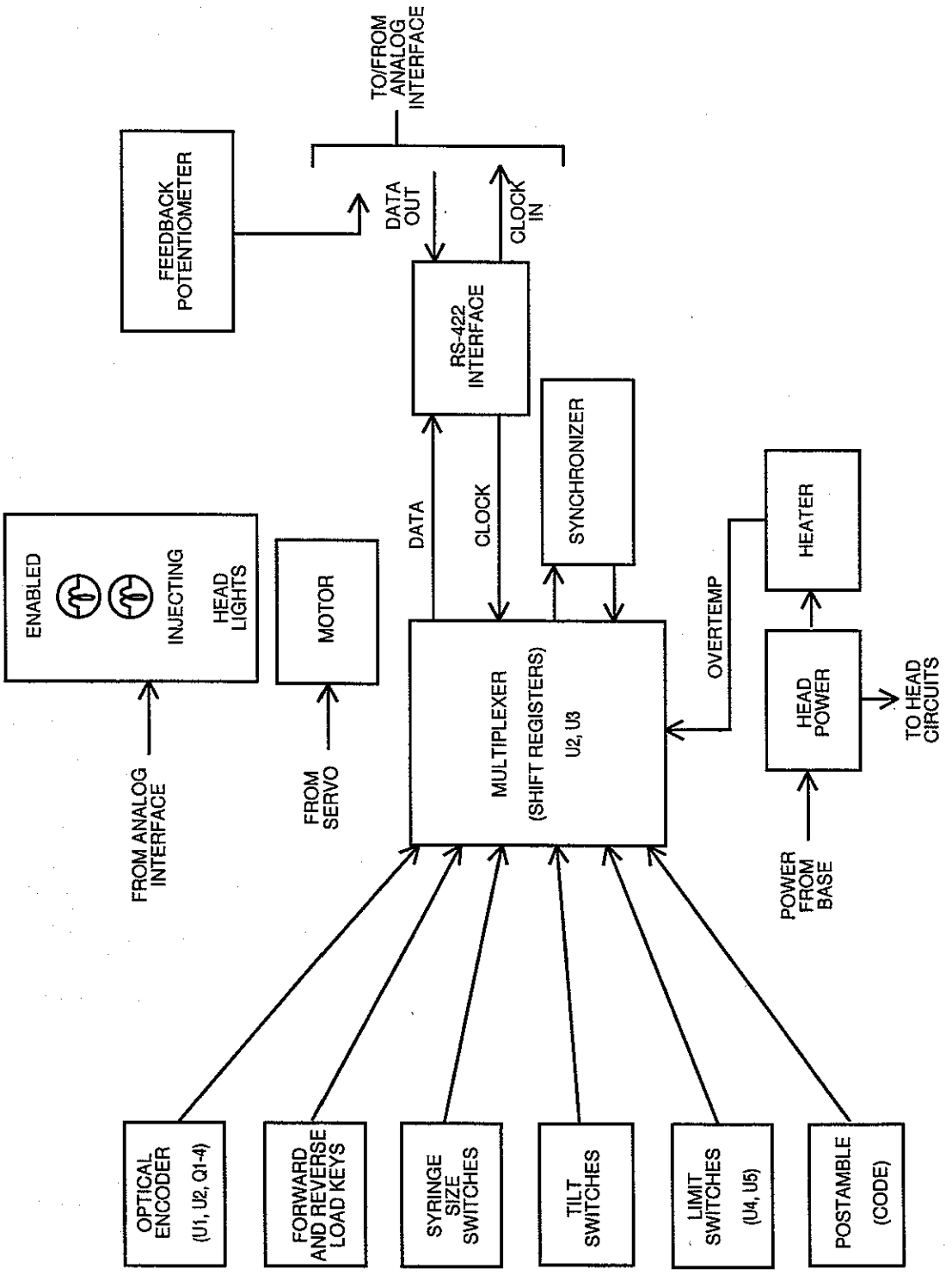


Figure 4-9
Powerhead Block Diagram

UNIVERSAL INTERFACE

The Angiomat 6000 has a Universal Interface board which handles signals from the 10-pin universal interface connector.

Major Functions

The universal interface couples the Angiomat 6000 to external start and film changer connections through the column-mounted connector J4. The injector can instruct the film changer to start as well as be instructed to start from a start switch or a remote switch closure.

The board provides optical isolation for noise immunity and to protect the other circuits in the injector. The board contains its own isolated power supply for the optical isolators.

Inputs and Outputs

The universal interface has connections to external devices, and to the circuits within the Angiomat 6000:

Input	From/Function
Start switch	From hand start switch; closed to inject.
Remote start	From external start switch connected to J4; closed to inject.
Inhibit switch	From external circuit connected to J4; closed to inhibit the start switch.
Film changer signal	From main processor; signals when to close the connections to film changer.
Switched AC line	From servo; for on-board isolated supply.
Injecting Signal, Handswitch *(Switch selectable)*	From analog interface; signals when the injector is injecting. From handswitch; signals when the handswitch is closed.

Output	To/Function
Start signal	To analog interface; signals when standard hand start switch is closed.
Remote start signal	To analog interface; signals when remote start switch (connected to J4) is closed.
Film changer	To external device through J4; relay contacts are controlled by Angiomat 6000 and will close when film changer is to be triggered.